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EXPERIMENTS WITH PLANT HORMONES IN THE PROPAGATION OF WILDLIFE FOOD AND COVER

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A basic step in the restoration of depleted game ranges is the production of vegetation meeting the food and cover requirements of the animals involved. Of importance in management are the rapidity and certainty with which such vegetation can be established. The use of cuttings hastens results and is an improvement over the use of seedlings from the standpoint of survival. It makes for economy also in that nursery overhead and labor costs can be reduced. Moreover, the growing of cuttings directly from trees, shrubs, and vines of proved worth assures high quality in the planting.

To suggest and, it is hoped, promote the development of such techniques, the writers present the results of some recent experiments in the rooting, after treatment with plant hormones, of cuttings from bittersweet, frost grape, red mulberry, and hawthorn. These four species—two vines and two small trees—were chosen because of their usefulness to wildlife, and the cuttings were taken from individuals showing pronounced fruitfulness, certain silvical characteristics, or desirable habits of growth.

PERTINENT LITERATURE

The problem of inducing plant cuttings to root has engaged the attention of propagators for many years; and certain horticultural practices, based on both trial-and-error experience and experiment, have long been in use. Only relatively recently, however, has there been experimental evidence that special treatments will increase the proportion of cuttings that root and the amount of root system developed.

The first experiments with treatments were based, according to Small (1923), on the reported acidity of roots, a circumstance which led Sir Isaac Bayley Balfour to water oak cuttings with an aqueous extract of peat moss. He obtained a significant increase in the proportion of cuttings to take root and found that the time required was reduced from about ten months to somewhat less than two. Small also reported experiments with species difficult to root, in which positive results were obtained by treating privet cuttings with water heated to 60°C. and with cold dilute acetic acid, and on both privet and Veronica cuttings watered with hot dilute acetic acid.

Inorganic and common organic chemicals also have been tested to some extent. Curtis (1918) reported that immersion of hardwood cuttings in 1 per cent potassium permanganate for 24 hours hastened rooting; and he attributed this effect to the combined

chemical, physiological, and germicidal actions of the salt. Winkler (1927) found that potassium permanganate, sodium peroxide, manganese sulphate, and potassium ferrocyanide increased the proportion of rooting grape cuttings from the normal 30 per cent to 90 and 100 per cent. Myers, Bowden, and Hardisty (1938) reported that potassium permanganate was more effective in inducing Kudzu vine cuttings to root than any of three commercial plant hormones tested.

Curtis (1918) found also that immersion of mature wood cuttings in 5 per cent cane sugar solution retarded growth, although the same treatment of tomato cuttings brought about quicker rooting. Chadwick (1933), who has made tests with vinegar (acetic acid), potassium permanganate, sugar, and peat on many kinds of plants, succeeded especially in stimulating the rooting of Evonymus and lilac cuttings.

A large literature exists regarding the effects of various derivatives of indole and other complex compounds upon root formation by herbaceous plants; much less has been published regarding the effect of these plant hormones upon woody cuttings, and that largely with regard to those from greenwood.

Literature dealing with treatment of cuttings has been summarized briefly by Snow (1938) and Afanasiev (1939). Snow has reported, also, experiments showing that cuttings of the aspens *Populus grandidentata* and *P. tremuloides*, if taken late in January and early February (in Connecticut), are little affected by treatment with indolebutyric acid but, if cut in "the latter part of March just as the leaf buds are beginning to sweil," can be rooted up to 65 per cent with the aid of that material. Afanasiev has reported that particular concentrations of indolebutyric acid, used for stated time periods, stimulate root production of greenwood cuttings of *Betula papyrifera*, *B. opulifolia*, *Acer rubrum*, and a white poplar hybrid, *Populus alba*×*P. nivea*, but do not stimulate cuttings of *P. tremuloides* and *Acer saccharum*.

The effect of plant hormones on dormant cuttings has not been much investigated. Hitchcock and Zimmerman (1936) tested aqueous solutions and lanolin preparations of certain growth substances on a number of woody species and found that the aqueous solutions effectively promoted root production by *Ilex*, *Taxus*, *Hibiscus*, and *Pachysandra* and that lanolin preparations of indoleacetic and indolepropionic acids consistently stimulated rooting of Japanese maple (*Acer palmatum*). Both Snow (1938) and Hutchings and Larsen (1929) regarded as dormant the cuttings which they rooted successfully. Snow stated, however, that his were taken in early spring and that cuttings collected in January-February were not affected by treatment. Hutchings and Larsen's cuttings, although made in November, were not planted until February and were treated by irrigation through February and March.

PRESENT EXPERIMENTS

The experiments here reported deal exclusively with dormant cuttings. The cuttings were taken while dormant, were treated while dormant, and were kept in the propagating bench during the dormant period. The readings were

taken just at the close of dormancy.

Materials and Methods. The cuttings used were obtained from four individual native plants, bittersweet (*Celastrus scandens*), frost grape (*Vitis cordifolia*), red mulberry (*Morus rubra*), and hawthorn (*Crataegus* sp.). Approximately 350 cuttings of each, nearly 1,400 in all, were subjected to the same experimental procedure, except for variations in concentration of the plant hormones.

The materials used for the treatments were Auxilin, Hormodin, and potassium permanganate. About 90 cuttings from each plant were treated with each material, and 75 were left untreated as checks. Cuttings were immersed for 24 hours in aqueous dilutions of the plant hormones and for 30 minutes in a potassium permanganate solution containing 0.89 gram of the salt in each 1,000 milliliters. Cuttings used as checks were not soaked even in water.

The greenhouse bench was divided into five compartments. One compartment was planted with about 75 Auxilin-treated cuttings of each plant, the next compartment with a similar number of Hormodin-treated cuttings, the third with potassium permanganate-treated cuttings, and the fourth with all the checks. In the fifth compartment lots of about 15 cuttings representing each handling on each plant were set in random arrangement as to treatment.

The bench soil, consisting of equal parts of quartz sand and peat moss, by volume, as recommended by Hitchcock and Zimmerman (1936), was kept moist but not wet. The greenhouse was maintained at approximately 70°F.

The cuttings were treated December 20 and 21, 1938, set in the propagating bench December 21, and kept there until March 31 and April 1, 1939, on which dates they were raised and examined. A period of 100 days was thus permitted for rooting.

Upon removal of the cuttings from the bench, the numbers dead and alive and the number that had rooted were recorded. An attempt was made, also, to determine statistically the differences in profusion of rooting between rooted check cuttings and rooted treated cuttings. As each rooted cutting was removed from the bench, the length of each root originating from the stem was determined to the nearest centimeter by means of a scaling board having concentric rings at 1 cm. intervals. The number of roots and the length of each was thus recorded for each cutting. From these data the mean number of roots produced per rooted cutting and also the mean root length have been computed for each treatment.

Branch roots were not counted or measured, since branching is probably an expression of factors that operate to some extent independently of treatment, such as the age of the main root from which branches arise, the texture of the soil, and the rooting character of the species.

Results with Bittersweet. The bittersweet cuttings were taken October 15, 1938. Although the season's wood was mature at the time, the cuttings were stored in moist sand in an unheated shed until treated and were twice subject to overnight freezing temperatures. Hormodin was used at a strength of 60 "BTI" units and Auxilin at 40 mg.

TABLE 1

ROOT GROWTH OBTAINED IN 100 DAYS ON BITTERSWEET CUTTINGS

Treatment	Number of cuttings used	Per cent of cuttings taking root	Mean number of roots per cutting	Mean root length per cutting in centimeters
Check	75	4.0	1.3	13.3
Auxilin	91	37.4	9.8	36.3
Hormodin	90	36.7	10.4	45.1
$KMnO_4$	88	4.5	6.7	33.7

to 1,000 ml. of water. The results obtained are shown in Table 1.

Results with Frost Grape. The frost grape cuttings were taken December 20, 1938, brought immediately into the laboratory and treated the same day. Hormodin was used at a strength of 60 "BTI" units, and Auxilin at 40 mg. to 1,000 ml. of water. The results obtained are given in Table 2.

anthracnose, which attack and sometimes kill cuttings. In our experiments the proportion of dead, non-rooting check cuttings was undoubtedly increased by black rot; also, 3 of the 43 rooted check cuttings and 12 of the 48 rooted cuttings treated with potassium permanganate were killed by disease after having rooted but before data were taken. None of the rooted cuttings treated with Auxilin or Hormodin died from disease attack after striking root.

TABLE 2

ROOT GROWTH OBTAINED IN 100 DAYS ON FROST GRAPE CUTTINGS

Treatment	Number of cuttings used	Per cent of cuttings taking root	Mean number of roots per cutting	Mean root length per cutting in centimeters
Check	75	57.3	11.0	65.8
Auxilin	93	31.2	10.5	54.4
Hormodin	91	28.6	15.8	72.4
$KMnO_4$	87	63.2	8.3	45.9

The frost grape cuttings differed from the other cuttings in that they sent out roots from one or two nodes above the base as well as from the base. The number of roots produced by the check grape cuttings was therefore larger than the number produced by the checks of the other plants; but the effect of treatment is not proportionately apparent in the number of roots produced by the treated grape cuttings.

Difficulty attends propagation of grapevines by cuttings because of diseases such as black rot, dead arm, and

Results with Red Mulberry. The red mulberry cuttings were taken December 19, 1938. Hormodin was used at a strength of 40 "BTI" units and Auxilin at 40 mg. to 1,000 ml. of water. The results obtained are given in Table 3.

Results with Hawthorn. The hawthorn cuttings were taken December 20, 1938, and were brought immediately into the laboratory and treated the same day. Hormodin was used at

TABLE 3

ROOT GROWTH OBTAINED IN 100 DAYS ON RED MULBERRY CUTTINGS

Treatment	Number of cuttings used	Per cent of cuttings taking root	Mean number of roots per cutting	Mean root length per cutting in centimeters
Check	75	0	0	0
Auxilin	80	5.0	1.2	17
Hormodin	93	0	0	0
$KMnO_4$	90	1.1	1.0	4

a strength of 40 "BTI" units and Auxilin at 80 mg. to 1,000 ml. of water.

Of the 338 cuttings used, not one put forth roots during the 100 days allowed in the propagating bench. At the time they were lifted, only 11 were still alive, and these 11 were so distributed among the check and treated series as to give no suggestion of any effect from treatment.

Summary of Results. From the data given in the foregoing tables, the effects of treatment may be compared as to the difference from the checks in (1) proportion of cuttings to root; (2) number of roots produced per cutting; and (3) average root length produced per cutting. These comparisons are made in Table 4.

On the bittersweet cuttings all three of the materials used were effective in all the respects considered. Auxilin and Hormodin, in the concentrations used, were approximately equal in effect and greatly surpassed potassium permanganate.

On the frost grape cuttings both Auxilin and Hormodin appeared definitely to inhibit the setting of roots, and only potassium permanganate stimulated cuttings to set root. As to mean number and mean length of roots per rooted cutting both Auxilin and potassium permanganate proved inhibitive, but Hormodin gave a small stimulative effect.

On the red mulberry cuttings both Auxilin and potassium permanganate were questionably effective in inducing a small number of cuttings to strike root and, hence, in inducing production of a greater mean number and mean

TABLE 4

EFFECT OF TREATMENTS ON CUTTINGS, EXPRESSED AS DIFFERENCE FROM THE CHECKS, IN PROPORTION OF CUTTINGS TAKING ROOT, IN NUMBER OF ROOTS PER CUTTING, AND IN ROOT LENGTH PER CUTTING

Kind of cutting	Difference from check in per cent of cuttings taking root			Difference from check in mean number of roots per cutting			Difference from check in mean root length per cutting, in centimeters		
	Auxilin	Hormodin	$KMnO_4$	Auxilin	Hormodin	$KMnO_4$	Auxilin	Hormodin	$KMnO_4$
Bittersweet	+33.4	+32.7	+ .5	+8.5	+9.1	+5.4	+23.0	+31.8	+20.4
Frost grape	−26.1	−28.7	+5.9	− .5	+4.8	−2.7	−11.4	+ 6.6	−19.9
Red mulberry	+ 5.0	0	+1.1	+1.2	0	+1.0	+17.0	0	+ 4.0
Hawthorn	0	0	0	0	0	0	0	0	0

length of roots. On the hawthorn cuttings none of the materials used was effective in the strengths used.

CONCLUSIONS

Although the experiments herein reported were limited to a relatively small variety of tests, a much larger number of specimens was used for each test than usually has been employed in experiments with greenwood cuttings; the results may therefore have added reliability.

The treatment of dormant bittersweet cuttings with either Auxilin or Hormodin appears to be an advantageous procedure, since these materials induce cuttings to root in proportions ranging around 33 per cent greater than is ordinarily obtained with untreated cuttings. The treatment of dormant frost grape cuttings with potassium permanganate is also advantageous, but only to the extent of about 6 per cent over those without treatment.

No significant advantage accrued from the treatment of dormant cuttings of mulberry and none from the treatment of hawthorn cuttings with any of the materials used, in the concentrations tested. In the case of red mulberry it is likely, however, that some treatment designed to break dormancy, followed by stimulative treatment, would be advantageous, since leafy cuttings of the white mulberry are known to respond satisfactorily to very mild concentrations of one of the plant hormones.

The failure of all treatments on the hawthorn cuttings, which was not unexpected, emphasizes the need of a rapid method of propagation for this valuable tree. Hitchcock and Zimmerman (1936) have reported failure with greenwood *Crataegus* twigs treated while still on the tree with highly concentrated lanolin preparations of growth substances. At present the propagation of *Crataegus* depends on the germination of seeds, which is both uncertain and slow. The seeds often are heavily infested with insects (in one reported lot, to the extent of 75 per cent) and sometimes are without embryos (as many as 10 per cent), so that not more than 15 per cent may actually be capable of germination. They require, besides, to be submitted to a special temperature (41–50°F.) for as long as a year before they will germinate.

The negative results here reported are to be regarded as applying only to the concentrations of materials used. With other concentrations, different, even opposite, results might be secured. The problem needs further and much more comprehensive investigation.

SUMMARY

Nearly 1,400 dormant cuttings, about 350 each of wild bittersweet, frost grape, red mulberry, and hawthorn, were treated with Auxilin, Hormodin, and potassium permanganate solutions, to determine whether these substances would bring about worthwhile increases in the proportion of cuttings striking root during the dormant period, in the number of roots produced per cutting, and in the total root length per cutting.

The cuttings were treated with the concentration of each material deemed most likely to prove effective. Auxilin was used at the rate of 40 mg. per 1,000 ml. of water for bittersweet, frost

grape, and mulberry and 80 mg. per 1,000 ml. for hawthorn; Hormodin was used at the rate designated by the manufacturers as 60 "BTI" units for bittersweet and frost grape and 40 "BTI" units for mulberry and hawthorn; and potassium permanganate was used at the rate of 0.89 g. per 1,000 ml. for all cuttings. A rooting period of 100 days was allowed.

Bittersweet cuttings responded well to treatment with both Auxilin and Hormodin but hardly at all to potassium permanganate. Frost grape cuttings responded to treatment with potassium permanganate but were inhibited by Auxilin and Hormodin. Red mulberry cuttings responded slightly to Auxilin and potassium permanganate but were unaffected by Hormodin. Hawthorn cuttings were not affected by any of the treatments.

It is considered that other results might be obtained with each of the materials, if tests were run with different concentrations, and that the data presented herewith apply only to the concentrations at which the materials were tested.

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BANDING WOODCOCKS ON PENNSYLVANIA SINGING GROUNDS[1]

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Late in the afternoon of March 26, 1939, while working on an area near State College, Pennsylvania, in connection with a forest type-game range study being conducted by the Pennsylvania Cooperative Wildlife Research Unit, the writers noticed that several male American Woodcocks (*Philohela minor*) were utilizing parts of the area as singing grounds. This section, although unlike most woodcock breeding grounds, was found to have a fairly heavy concentration of singing males. This opportunity, in view of the fact that attempts in the past to trap and band adult woodcocks have met with little success, led the writers to carry on a trapping technique and population density study. The work was done under the supervision of Dr. Logan J. Bennett, U. S. Bureau of Biological Survey; Dr. P. F. English, Department of Zoology and Entomology, Pennsylvania State College; and Dr. W. C. Bramble, Department of Forestry, Pennsylvania State College.

In Centre County, between two mountain ranges lies a broad expanse of agricultural land called Nittany Valley. It is in this valley, a few miles west of Pennsylvania State College, that an area known as "the great pine barrens" is found. The part of the barrens covered by this study is representative of a type that occurs also in many other sections of Pennsylvania. The area is slightly higher in elevation than most of the surrounding agricultural lands, a large proportion of it being between 1,150 and 1,300 feet above sea level. One ridge that runs through the region is a little more than 1,500 feet in elevation, but aside from this ridge the topography is gently rolling, with some broad flats and many smaller ridges.

There are no streams in the section of the "pine barrens" where this study was carried on, and during the hot summer months very little water is available. In spring and early summer the many sinkholes that are scattered throughout the area hold considerable water, but all except a very few of these dry up as the summer heat approaches. There are, however, a small pond and a large ore pit that contain water during the entire summer.

The part of the barrens with which this study is concerned comprises 5,200 acres, of which 950 acres in the lowest areas contain openings suitable for woodcock singing grounds. The rest of the tract is practically devoid of open areas and contains either dense growths of scrub oak (*Quercus prinoides* and *Q. ilicifolia*) and pitch pine (*Pinus rigida*) or fully stocked stands of mixed oak (*Quercus alba, Q. coccinea, Q. prinus, Q. borealis* var. *maxima*, and *Q. velutina*), with many clumps of aspen (*Populus*

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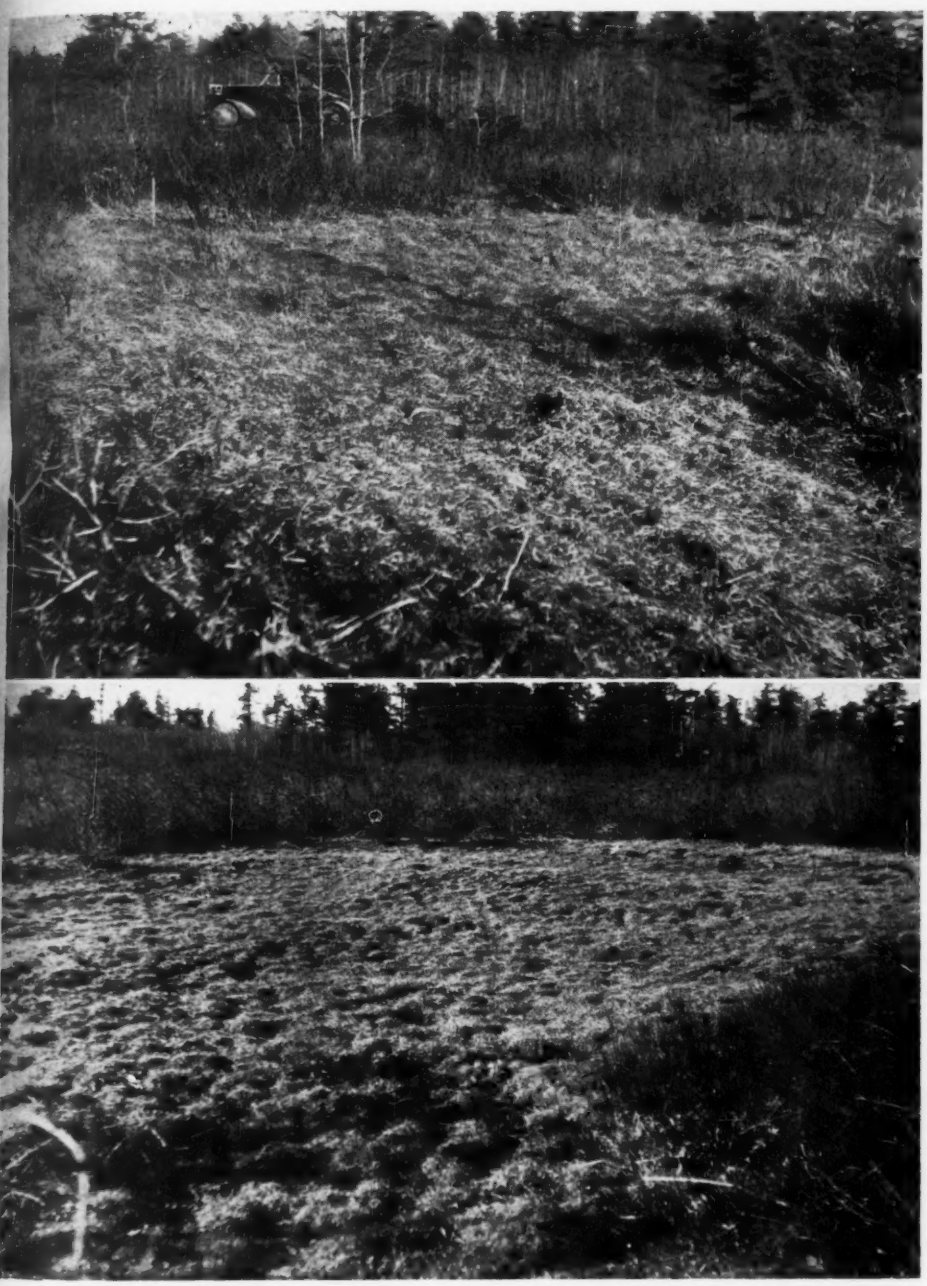

Upper.—Primary singing ground of woodcock No. 3.
Lower.—The largest woodcock singing ground observed in the barrens.

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tremuloides and *P. grandidentata*) in both types. These higher regions which contain no openings may, however, serve as nesting cover for many of the breeding birds. One nest was found April 20 in the dense scrub oak growth on the top of one of the smaller ridges.

Forty singing males and their singing grounds were located on the 950-acre tract, and at least five other males were heard whose singing grounds were not definitely located. It was found on the study tract that there was 1 singing male to approximately every 21 acres of available singing ground territory. If woodcocks were positively known to be monogamous—as are many shore birds—then the population of this area could be determined easily by doubling the number of singing males. Some evidence was obtained, however, which indicated that woodcocks may at times be polygamous.

The openings available for singing grounds were so numerous that each singing male probably had his choice among a large number. The shortest distance between any two singing grounds was 215 yards. Of 38 singing grounds, four were 215 to 250 yards apart; six, 250 to 300; ten, 300 to 350; seven, 350 to 400; three, 400 to 450; and eight, over 450 yards apart. Aldous and Mendall (1939) state that in Maine two males were found to be singing only 70 yards apart.

Although the singing grounds varied considerably in size and shape, they were very similar in other respects (Plate 1). A detailed description of a typical one will be sufficient to illustrate the type. Woodcock No. 3 used three closely located small openings. The one most often frequented was a fairly level area, 24 feet wide and 42 feet long, covered with wild oat grass (*Danthonia spicata*), bluegrass (*Poa pratensis*), and numerous scattered scrub oak and panicled dogwood (*Cornus paniculata*) stems, 6 to 12 inches high (Fig. 1). The open area was surrounded by a dense growth of scrub oak, panicled dogwood, and blueberry (*Vaccinium* spp.), 2 to 4 feet in height. There were two similar open areas that were distinctly separated from the primary singing ground by the surrounding low, dense vegetation. One auxiliary open area, 10 feet wide and 13 feet long, was 45 feet southwest of the main singing ground; while the other (11 by 14 feet) was 100 feet to the south. These auxiliary singing grounds were used occasionally during the morning and evening singing periods.

It is generally believed that the male woodcock usually has only one singing ground, but it was found that within the barrens area most of the males used two or three neighboring small openings similar to those described. In most cases, the birds used one of these areas much more frequently than the others. On several occasions it was noted that nearby areas apparently just as well suited for singing grounds, were not used.

The average size of the primary singing grounds was 21 by 37 feet; the largest (See Fig. 2) was 47 by 54; and the smallest, 5 by 12 feet. These were small compared with those found in the Maine woodcock study, of which Aldous (1938) gives the minimum size as about 1 chain square.

Interest in the territorial instinct exhibited by male woodcocks on their singing grounds, led the writers to in-

vestigate the reactions of occupants to an intruding male. On March 29, 1939, a male woodcock was collected and mounted in a normal standing position. The completed decoy was a rough-looking affair without glass eyes, and it was too narrow to resemble an average female. The mounted bird was placed in the center of a known singing ground before the male came in for the evening. The wires protruding from the feet of the decoy were stuck into the ground to hold it firmly in place.

This first experiment took place on March 31, 1939. A full moon enabled the observer, who was concealed in shrubbery 25 feet from the decoy, to see the general movements of the singing male at all times. Upon the arrival of the male on the singing ground and again after the first two flight songs, he landed on one corner of the singing ground and apparently failed to see the decoy. At the conclusion of the third flight song, the male alighted about 6 feet from the mounted bird, which he noticed immediately. He did not "peent" as usual, but repeatedly uttered a "took-oo" note (for woodcock notes, see Pettingill, 1936). After raising his wings to a vertical position high over his back with the wing tips pointed out-

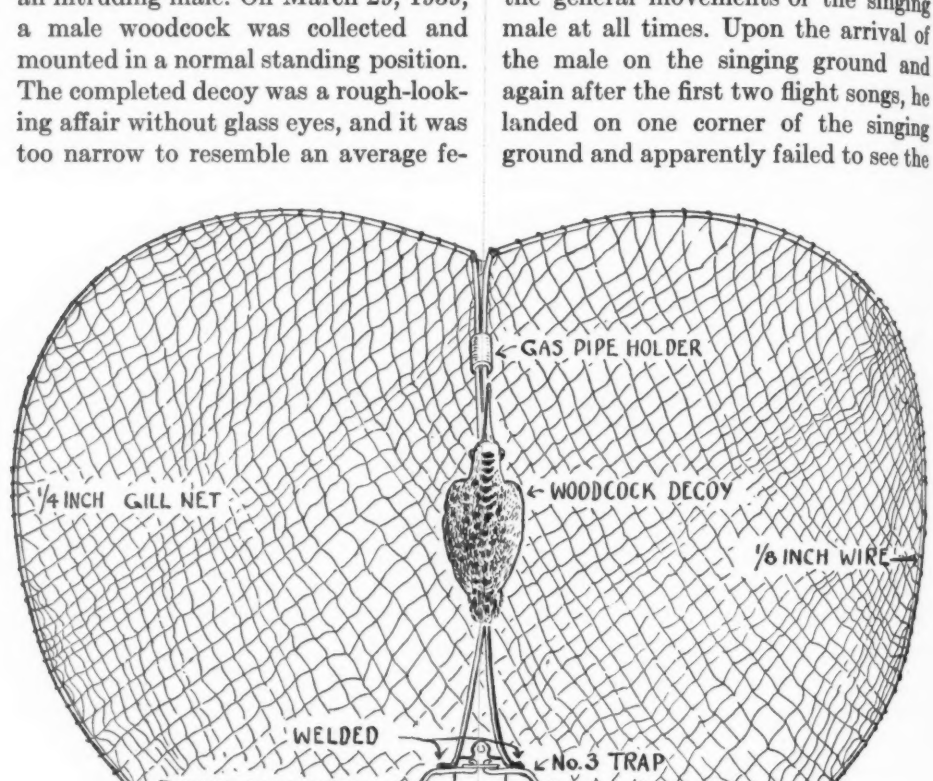

Fig. 1. The Pennsylvania woodcock trap. (Drawn by Ross T. Mitchell.)

ward, he walked rapidly on stiffened legs toward the decoy. While approaching the mounted bird, he frequently dipped his wings, the tips moving about 2 inches. In this position he walked past the decoy and approached it posteriorly. He paused momentarily at a point about 3 inches behind the decoy, then trod it in an attempt to copulate. Before the fourth flight song the male woodcock attempted to copulate with the decoy four times, treading it from both sides after trying twice from the rear. While upon the back of the stuffed bird, the male fluttered his wings constantly, but ceased to utter the "took-oo" note—which had been repeated regularly from the time he saw the decoy until the attempted mating.

More time and greater energy were spent in the display before the decoy during the latter part of the singing period, and attempts to copulate were fewer and less persistent. Dipping his uplifted wings and uttering the "took-oo" notes, the male often walked around the mounted bird during that time. The legs of the male were straight and stiffened during the display, and the bird often stumbled over small obstructions in his path. After several attempts to copulate, the male sometimes walked to a position directly in front of the decoy, where he stood with upraised wings and bobbed and bowed before the mounted bird at a distance of about 3 feet.

The male remained on the singing ground from 6:42 P.M. until 9:01 P.M. during which time 27 flight songs were made. Fourteen of these were from the primary singing ground, and the remaining 13 were from the auxiliary singing areas. While the male was on the primary singing ground, 21 attempts to copulate with the decoy were recorded. The length of this singing period was abnormally long, and the number of flight songs was similarly high. Although these observations were recorded on a moonlight night and such weather conditions are conducive to longer singing activities, it was thought that the presence of the decoy had a decided effect on the male bird and the number of his flight songs.

After the first observation of attempted mating with the decoy by the male woodcock, the writers observed many singing males and their reactions to the decoys. The observers were usually stationed 10 to 40 feet from the mounted bird. The more minute details of the display and actions were seen at the beginning of the evening flight period, and the general movements of the birds could occasionally be seen throughout the evening. A great majority of the observations were made after a trap had been placed under the mounted bird; under those conditions the normality of the male's actions is questionable.

The reactions of singing male woodcocks to the decoys varied with the individual. All were not inclined to accept the mounted birds so readily as was the case with the first one observed. Approximately 22 per cent of the 31 males observed paid no attention to the decoy, but carried out their normal routine in its presence. Thirteen per cent attempted copulation after initial indifference toward the mounted birds, while 52 per cent readily attempted copulation. Some decoys were poorly located, so that the remaining 13 per

cent of observed birds apparently never saw them.

Practically all of the observed males stopped "peenting" when the decoy was first noticed, but all continued to utter the "took-oo" note. A few failed to raise their wings at the sight of the mounted bird, and these soon resumed their "peenting" and usual singing activities. In some cases, however, the males raised their wings only to lower them without taking a single step in the direction of the decoy. The normal routine would then continue. Others walked toward the mounted bird with raised wings and then became disinterested. Birds that showed these various phases of disinterest when first sighting the decoy, often attempted copulation with it after subsequent flight songs. On several occasions the decoy was hit lightly about the head by the bill of the male after he had lowered his wings, and in one case the lower mandible of the mounted bird was lightly tapped.

Pettingill (1936) cited examples of male woodcocks strutting in a manner similar to the turkey gobbler and presumed that the performance may have taken place before the female on the singing ground. No such actions were observed by the writers while the male was on the singing ground in the presence of a decoy. When approaching the decoy, males on two occasions spread their tails in a fan over their backs.

From testing the reactions of singing male woodcocks toward mounted birds placed on the singing grounds, plans of using a decoy to attract males for trapping evolved. Previous to the trapping experiment, jack lights and landing nets had been used with but little success in attempts to catch the singing males.

The first trap constructed was a modified single-spring, No. 1½ steel trap. A single piece of ¼-inch wire, bent in a semi-circular shape and welded to each of the jaws, in effect enlarging them to 20.5 inches by 28 inches, supported a net of minnow seine of ¼-inch mesh. To hold the pan tightly against the small wooden block which was placed beneath it to prevent premature release, a rubber band was stretched between the pan and the base of the trap. When the block was removed by pulling the attached cord, the rubber band rapidly pulled the pan down and released the trap. After the trap had been set on the singing grounds, the decoy was placed in the center, about 10 inches in front of the pan and facing away from it.

This trap was first used on April 3, 1939, at which time a woodcock was caught. Continued use proved that the trap was too slow to catch all birds, several easily escaping capture even when they were attempting to copulate. To obtain a faster trap, the writers adapted the previously described features to a No. 3 jump trap. This trap was used from April 13 to May 10. Eleven male woodcocks were caught during this period, but four birds attempting copulation escaped capture; also birds standing beside the decoy could not be caught.

Upon arrival at the primary singing ground, an occasional male had shied from the trap covered by minnow seine and had then sung from an auxiliary singing area. Hence, the brown minnow seine was replaced by dark green gill netting (1-inch mesh) to give the trap added speed and to make it less conspicuous. The shiny metal parts of the trap, also, were painted to blend with

the vegetation of the singing ground. During the remainder of the trapping period, May 11–22, this type of trap was used to catch three more woodcocks. The gill netting was a decided improvement over the minnow seine in speed and obscurity, but it had a tendency to entangle the head and wings of the birds and make them difficult to remove. The covering which now appears ideal for this trap and which will be used in the future is one of similar material but of $\frac{1}{4}$-inch mesh (Fig. 1).

The efficiency of the modified trap cannot be adequately appraised, as by the time it was ready, the courtship period was waning and the birds were not so easily trapped. Persistent attempts to catch the singing woodcocks rendered several of the birds that were missed earlier in the season—through faulty traps and techniques—shy of both traps and decoys. Pertinent, however, is the fact that of the 27 birds that actually saw the mounted birds, 20, or 74 per cent, attempted copulation the first night. The actions of the remaining 7 birds may be attributed to several defects, all of which may be remedied. The decoys, without eyes, were by no means the best, especially after weeks of hard usage. The brown minnow seine was very conspicuous on some singing grounds, especially against green vegetation. Some birds seemed reluctant to step upon the seine and stopped at the edge of the trap. This condition was remedied by the use of the green gill netting. It was found that balsa wood bodies made the decoys stand up much better to the fluttering of the trapped males and roughing by the traps.

The writers lost considerable time through not having the traps and decoys placed within sight of the singing males. Hence, a first and very important step in the trapping was to locate that part of the singing ground most consistently used. It also proved desirable to have the trap and mounted bird set upon the selected area before the woodcock came in for the evening, and to have the observer in a position to see the entire trap and decoy. Old droppings were often very helpful in indicating where to place the trap. A level spot was selected upon which the trap was set. The more conspicuous parts of the trap were then camouflaged with a light covering of dried grasses or leaves. Concealment of the observer was not of great importance if he was off the singing ground and remained motionless. The trap was never to be released until the male woodcock was on the back of the decoy, trying to copulate with it. It was better to hesitate for a few seconds even after the bird was in the copulating position before pulling the cord.

The reactions of singing male woodcocks to other live birds (presumably females) suggested attempts to call them to those traps that proved not to be favorably placed. Male birds were often seen to chase any woodcock flying low over the singing area. While in pursuit, the male uttered a cackling sound (as described by Pettingill, 1936). It was also noted that a few "peents" by birds near the singing ground caused similar reactions.

Three very different types of "peents" none of which closely resembled those of the woodcock, were produced by the writers. All were successful, nevertheless, in calling the males to the decoy, to a total of 9 individuals out of a possible 24. The singing males responded by

flying toward the sound, cackling as they flew. If close, the distance was covered in a single flight. One bird was called from 75 yards, and this distance was covered in three or four low flights. Each time the bird alighted, he began to "peent" vigorously, and more calls by the observer were necessary to coax him to the trap. Another bird, upon hearing the false "peent," flew to its approximate source and, apparently searching for the "peenting" bird, circled low over the vegetation. The singing birds alighted surprisingly near the source of the false "peent," often coming within 3 feet of the caller. When attempting to call a woodcock to the trap, the best stand was directly behind the decoy and in line with the singing male. The writers found that if a bird could be called to a position where he saw the decoy, an attempt to copulate might be expected. Singing males, however, required no calling when the traps were well placed.

When trapped, the birds fluttered about considerably in the netting; but when gently removed they became very docile and rested quietly in the hand while the bands were placed on their legs.

Surprising as it may seem, the birds were not greatly frightened by the trapping experience. The first woodcock was trapped on April 3 and marked on the head and feet with white paint because no bands were available at that time. When released, it flew a short distance to an auxiliary singing ground and "peented" vigorously. After one flight song from that area, the bird alighted about 10 feet from the place where he had been trapped and then continued his evening flight song in the normal manner. On April 13 this bird was caught again on the same singing ground. After being banded and released, he returned within 5 minutes to the place where he was trapped and continued singing. This incident is rather typical of the trapped birds. Usually they flew but a short distance after being released and within 5 minutes had returned to their normal singing activities. Some flew a little farther than others or returned after a greater lapse of time. These observations show that this trapping method apparently does not injure or frighten the males and does not greatly disturb their singing procedure.

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NOTES ON A METHOD FOR CENSUSING WHITE-TAILED DEER IN THE SPRING AND SUMMER

Arnold B. Erickson

Deer populations have been censused by several methods. Among the best known of these are: the drive of a square mile of land, census by counting the deer in yards, and the use of indices, either tracks in the snow or beds in the grass. Each of these census methods has its strong as well as its weak points.

The census drive is essentially a method to be used in the autumn after the leaves have fallen. It can be employed during the summer, but the density of the cover during that period renders it less reliable. This method is valuable in that it can be used in the early fall before the hunting season, when it is necessary to know the deer population of an area so that the proper hunting regulations may be made. Its drawbacks, however, are serious. For example, about 175 men are required to drive a square mile, and in normal times when C.C.C. labor is not available the cost would be prohibitive to most conservation departments. Then, too, the technique of the census drive is complicated and slow, with the result that if many samples of an area are censused it becomes a very time-consuming process.

The accuracy of a census by deer yard counts is influenced by the amount of winter snowfall. During a winter of light snow the deer, while they do take up winter quarters in yards, are less restricted in their movements, and for that reason more difficult to census. During hard winters when deep snow impedes their activity, the census by deer yard counts should prove very accurate. The fact, however, that this type of census must be conducted after, rather than before, the normal hunting season is a severe drawback unless it is preceded by another type of census previous to the hunting season. If this dual census is employed, the number of deer that may safely be taken from an area and the number actually taken are both known.

A census by track counts is dependent on snow, which means that in all probability, it would have to be conducted after the hunting season, since only rarely is there enough snow for track counts before the fifteenth of November in the Lake States. The technique of deer census by track counts needs great refinement if it is to be used with any degree of accuracy.

The use of summer deer beds as an index to the deer population of an area promises, in my opinion, to be a valuable aid in determining population densities. In the first place, this method can be used throughout the summer when the deer seek open, elevated situations in order to avoid mosquitos. It is possible by the size of the bed to determine, to a certain extent, the age class ofthe deer, but whether one could ascertain sex by the bed characteristics remains to be demonstrated.

With the defects and strong points of the foregoing deer census methods in mind, I attempted in 1937, while in the employ of the National Park Service as Student Technician in Wildlife, to

plan and put into practice in the St. Croix State Park, Pine County, Minnesota, a method for censusing deer in the spring and summer. The techniques of this method have by no means been perfected; yet I should like to offer my observations and suggestions on this procedure, which may be called the cruising census, so that those who are working with deer may, if opportunity presents, try it, point out its weaknesses, and improve upon it.

In censusing deer by the cruising method the following factors must be kept in mind: the distance between cruising lines, density of cover, running distance, flushing distance, sight distance, cover visibility, type of cover, and sex and age of the deer. Since fawns are little in evidence during the summer they may be disregarded as are young stock by cattlemen.

The distance between cruising lines depends on the mobility of the species in question and also on the density of the cover. Mobility as relates to cruising lines is called in this paper running distance, and is the average distance that the deer ran after being flushed. In this study the running distance appeared to be about a quarter of a mile, for that reason I used cruising lines at quarter mile intervals. It is my feeling that if the lines are at half mile intervals a more accurate census will result.

The flushing distance, which is the distance from the census taker that the deer first starts, averaged in the St. Croix Park 140 feet. Sight distance is a term used to indicate the distance from the observer that feeding or resting deer can be seen. This distance, too, is dependent on cover density.

The term cover visibility was coined to describe cover density; it may be defined as the distance that an observer is able to follow with his eyes a flushed deer through a stand of cover. It is the flushing distance plus the distance that the deer runs before it disappears. It was usually determined by noting the point at which the deer disappeared, and then pacing the distance from the observer to that point. It is possible that cover visibility might also be determined by the use of a light-meter, reading of which would indicate the amount of shade and hence the density of the cover, or by the number of trees or shrubs per acre.

If a deer census method is to be developed for spring and summer use, it is important to ascertain the cover visibility, since it must be admitted that fewer deer will be flushed from dense than from sparse cover. Once the average cover visibility of an area or of various samples of an area is known, the running distance and the flushing distance can be calculated more accurately.

In censusing by the cruising method the sex of the deer can frequently, but not always, be determined by antlers, udder, or size and shape of neck. Yearlings can usually be distinguished from adults.

The cruising census for deer as outlined above is a modification of King's method for censusing ruffed grouse. Despite the dissimilarity of the two species the basic principles of the method can be applied to deer.

The following remarks on the cruising census in the St. Croix Park are based on 38 observations of flushed deer. The average flushing distance was

140 feet, and the running distance varied from 70 feet to well over a quarter of a mile. Cover visibility was most accurately determined for the aspen types where it averaged 100 feet. In 18 of the 38 observations, deer were flushed from the various aspen cover types—aspen-bracken fern (*Populus tremuloides-Pteridium latiusculum*), aspen-hazel (*P. tremuloides-Corylus americana*), aspen-sweet fern (*P. tremuloides-Comptonia asplenifolia*), and aspen-panicled dogwood (*P. tremuloides-Cornus candidissima*). Of the other 20 observations 4 were made in meadow, one in alder (*Alnus incana*), 4 in jack pine (*Pinus banksiana*), 3 in pin oak (*Quercus ellipsoidalis*), one in Norway pine (*Pinus resinosa*), one in white birch (*Betula papyrifera*), one in black spruce (*Picea mariana*), one in hazel (*Corylus americana*), 2 in beaked willow (*Salix bebbiana*), and 2 in fields. The sex of 22 of the 38 animals was determined satisfactorily—10 male and 12 female.

The cruising census, like most censuses, has an optimum period during which it can be conducted. For example we found that fewer deer were flushed after the first of August than before this date. At least 3 factors seemed to be involved: first, the mosquito population, which will vary in any locality from year to year. In the St. Croix Park there is usually a marked decrease in their numbers after August first, thus making it less needful for deer to seek open situations. The second factor, one which seems to cause the deer to rely more on hiding than running, is density of the cover, which reaches its maximum in early August. Finally, the summer temperature is frequently hottest in late July and early August, a factor that might well cause the deer to seek deeper, cooler cover during the day. If the above observations are correct, deer census by the cruising method in the Lake States probably can be conducted with best results in May, June, early July and September.

The census figures for deer in the St. Croix Park were derived by the use of a formula that King devised for ruffed grouse which states that $P = \frac{AZ}{XY}$ where A is the total area, P the population, Z the number of deer flushed, X the miles of line cruised, and Y the average flushing distance (the flushing distance is doubled so as to account for land on both sides of the line that is cruised). I calculated the deer population on the 27,900 acres of park land at 557.12 head or 12.78 per square mile or 50 acres per head. The figures used in the calculation are given below.

A = 135,036,000 square yards.
Z = 38 deer flushed.
X = 56 miles or 98,560 yards of line.
Y = 46.725 × 2 or 93.45 yards.

Again I wish to emphasize the fact that if cover visibility for the St. Croix Park were known more accurately, the population could be determined more correctly. I believe, however, that the calculated population of 557 deer is close to the actual number.

It would be of much value if a large area could be censused during May, June, or early July by the cruising method, and then as a check on this method, censused again in the fall by driving.

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THE DIVING ABILITY OF THE BLACK DUCK

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The present investigation of the depth to which Black Ducks will dive for food resulted from a troublesome condition that developed during the course of trapping Canvasbacks, Greater Scaups, and Lesser Scaups on Cayuga Lake, near Ithaca, New York, in January and February, 1939. Black Ducks concentrated upon the baited water to such an extent as practically to exclude the divers from the area of the trap. This situation developed only after six to twelve inches of snow blanketed the upland fields, where the birds customarily fed, and at a time when ice covered much of the shallow water in which readily available food for dabblers could be found. Although the trap was located in two and one-half to three feet of water, Black Ducks and Mallards dived and secured the cracked corn bait with the greatest of ease.

That dabbling ducks possess the ability to dive is known by all who are interested in this group of birds. Forbush (1925) considers it probable that all dive to some extent as young birds, when courting, when wounded, or when flightless as a result of molting. Individuals among the writer's wing-clipped captive Black Ducks dive with the greatest facility when hard-pressed by man and may be as difficult to net as a captive Canvasback. Likewise during fighting incident to courtship behavior in the spring a pursued bird may dive repeatedly while rushing precipitously through the water in order to escape an aggressor.

It seems definitely established, however, that adult Black Ducks[1] do not dive ordinarily (Bent, 1923; Forbush, 1925; Phillips, 1923). That they will upon occasions dive for food has been shown by Phillips (1923) who reports that they cleaned up bait in water over his knees, and Dr. A. A. Allen informs me that he has observed them diving for natural food in three feet of water. W. L. McAtee states that about 1910 at the wharf on Knott's Island, N. C. he saw Black Ducks kept for decoys diving for corn thrown in the water, following the grains, and seizing them apparently as far down as five or six feet.

In order to determine the depth to which Black Ducks are able to dive and secure food on the bottom of a body of water, cracked corn was placed successively in five feet, seven feet and two inches, and ten feet of water. In each instance the position of the grain was marked by means of a buoy, after which the observer retired to a blind at the water's edge and followed the behavior of the ducks with 6× binoculars.

Some of the divers always were the first to locate the bait in its new position. Their feeding behavior apparently served to attract the attention of nearby Black Ducks, which shortly massed in numbers above the grain and dived again and again. The Blacks, by their boldness, aggressiveness, and close concentration soon discouraged the divers from further feeding attempts. As a re-

[1] No attempt is made to draw a distinction between *Anas rubripes rubripes* and *A. r. tristis*.

sult most of the latter would lose interest and swim away.

At the five-foot and the seven-foot two-inch depths, seventy-five Black Ducks and "puddle duck" Mallards concentrated upon the grain and dived again and again. Repeatedly both species were seen upon coming to the surface to snap their bills and gulp, or dabble with the bills and then swallow. This behavior continued until all grain had been consumed (as revealed by examination of the bottom at the five-foot depth where twenty-five pounds of corn had been placed).

The point at which the grain was placed in ten feet of water was located 150 feet from the blind. In this case only Black Ducks, to the number of thirty, concentrated and dived upon the bait. The behavior was as before. Seventeen different times the birds were distinctly seen to come to the surface, snap their bills, and go through swallowing movements.

The diving behavior itself is worthy of note. Preceding each dive a bird would assume a definite stance with neck fully extended upward and muscles tensed. Then with a powerful kick from both feet it would disappear beneath the surface of the water, the kick causing a splash of no inconsiderable proportions.

Although artificial food conditions were resorted to in this investigation, it does, nevertheless, demonstrate that the Black Duck possesses the ability to dive and secure grain placed in ten feet of water, a depth more than three times as great as previously recorded.

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A SURVEY OF THE PARASITES OF THE IOWA COTTONTAIL (*SYLVILAGUS FLORIDANUS MEARNSI*)[1]

B. B. Morgan and E. F. Waller

The ubiquity of the rabbit and the hare and their widespread use as laboratory animals have naturally resulted in their being submitted to numerous parasitological examinations. The first written record of a parasite being found in a rabbit appeared in 1674, when Leeuwenhoek described, in the bile of a rabbit, bodies which were in all probability, oocysts of *Eimeria stiedae*. Since that time numerous other investigators have reported a variety of both endo- and ecto-parasites.

During the past academic year, 1938–39, 210 cottontail rabbit carcasses were submitted to this laboratory for examination. One hundred and five of these were males and ninety-four females, while for eleven the sex was not determined, as only viscera were received. Some of these animals were collected in connection with a study of the life cycle of a trematode (*Hasstilesia tricolor*) and the remainder were submitted by state conservation officers and hunters as a result of reported outbreaks of tularemia in the state. Since the rabbits were all dead when received, it was impossible to study satisfactorily any protozoa that might have been present other than the coccidia and sarcosporidia. The specimens examined, came from twenty-one townships in twelve different counties.

[1] A contribution from the Iowa Cooperative Wildlife Research Unit, Project 570, in cooperation with the U. S. Biological Survey, the American Wildlife Institute, and the Iowa Conservation Commission.

Method of Procedure

The following method of treating the material was found to be the most satisfactory. When the rabbits were received, they were kept in a refrigerator at 40°F. for at least one hour. Following this chilling they were placed on a large sheet of wrapping paper and a 500-watt lamp was lowered over them. The heat, radiated by this lamp, activated the fleas so that they could be readily collected from the surface of the fur or from the paper. The fleas were put directly into ninety-five per cent alcohol. Later, specimens to be used in making permanent mounts, were taken from the alcohol and soaked in a ten per cent solution of potassium hydroxide for twenty-four hours. They were then washed in distilled water and passed through fifty, seventy, eighty-three, and ninety-five, per cent alcohol and then into carbol-xylol. They were mounted in gum damar.

When several carcasses arrived at the same time, it was often necessary to hold some of them for thirty-six or forty-eight hours; continued exposure at 40°F., however did not kill the fleas.

Ticks were preserved in a solution of chloroform in ten per cent formalin. Examination was made with the aid of a dissecting microscope, while the parasite was submerged in this solution.

After all of the readily available ectoparasites had been collected the carcasses were skinned. This facilitated

examination of the musculature for *Multiceps serialis* and *Sarcocystis cuniculi*. The body cavities were then opened and examined for *Cysticercus pisiformis* and the abdominal viscera removed. The stomach and small and large intestines were examined separately in the order named. The contents of each of these organs were placed in shallow, white enamel, 12″×18″ pans and running water was used to separate the ingesta and the parasites.

The nematodes were collected in a physiological saline solution to which had been added ten per cent of commercial formalin. They were later cleared in lacto-phenol for identification.

The small trematodes were fixed in Gilson's fluid or ten per cent formalin and stained with alum cochineal. Another stain that gave good results was a mixture of three parts of alum cochineal and one part of Delafield's hematoxylin. These methods are for entire mounts. The tapeworms were preserved by the rapid method described by Meggitt (1924) using ninety-seven parts of a saturated solution of carmine in forty-five per cent acetic acid and three parts of a saturated solution of ferric acetate in acetic acid. These solutions are kept in separate bottles and mixed in the above proportions just before using. The worms may be put in the stain alive or killed with formalin. They were left in the stain from five to thirty minutes according to size and then cleared in lactophenol. Permanent slides were prepared by staining with hematoxylin and mounting in gum damar.

The contents of the terminal portion of the colon and of the rectum of the rabbits were also collected and examined for parasite ova and coccidia. This examination was made by the sugar flotation technique for clinical fecal examination as described by Waller (1939). The parasites recovered by all methods are herewith listed and discussed.

ECTOPARASITES

SIPHONAPTERA

Family: *Pulicidae*

Cediopsylla simplex Baker. This flea was recovered from eighteen cottontails. Seventeen was the highest number recorded from one rabbit. This form was most prevalent during the winter months. It is characterized by both pronotal and genal combs.

Hoplopsyllus affinis Baker. This flea was found on nine rabbits. Twelve specimens were recovered from one animal. It lacks pronotal and genal combs.

Ctenocephalides canis Curtis. The common dog flea was found on four cottontails always in association with *Cediopsylla simplex* or *Hoplopsyllus affinis*. Not more than three dog fleas were found on a single rabbit.

ACARINA

Family: *Ixodidae*

Haemaphysalis leporis-palustris Packard. This tick was removed from the ears of two cottontails collected near Ames, Iowa, in April. One rabbit harbored four ticks, the other, two. This parasite is characterized by the second joint of the pedipalp being laterally produced.

ENDOPARASITES

PROTOZOA

Order: COCCIDIA

All of the 210 cottontail rabbits examined were infected with one or more species of coccidia.

Eimeria perforans Leuckart. This coccidium was found in the greatest number of rabbits. The oocysts were ellipsoidal and colorless. The micropyle was not readily discernible in oocysts taken from fresh feces. The average size of the oocysts taken from twenty rabbits was 26.4μ×16.2μ.

Eimeria irresidua Kessel and Jankiewicz. This coccidium was also found in the majority of the cottontails examined. It is a comparatively large transparent microorganism with a conspicuous micropyle. The average size of the oocysts from twenty rabbits was 36.5μ×18.4μ.

Eimeria magna Pérard. This species was not as common as either *E. perforans* or *E. irresidua*. The oocysts were large, ovoid and brownish and had a conspicuous micropyle. The micropylar end had the characteristic appearance ascribed to this species. Ocoysts from twenty-five rabbits had an average size of 34.8μ×24μ.

Eimeria leporis Nieschulz. This species was found in only one rabbit. The infestation was localized in the caecum and was manifested by grayish-white, circumscribed raised areas. These varied in size from those just visible to the naked eye to others as large as three mm. in diameter. The oocysts appeared cylindrical and for the most part slightly curved, giving them a bean-, or kidney-shaped appearance. They had an average size of 36.6μ×18.8μ.

Eimeria exigua Yakimoff. A coccidium was found in eight cases that very closely resembled one described by Yakimoff (1934), which he named *Eimeria exigua*. The oocysts were colorless and spherical and twenty-five of them averaged 14μ in diameter.

Eimeria paulistana Da Fonseca. In four rabbits an ovoid coccidium with a brown, double-striated wall and a distinct wide micropyle was found. Twenty occysts were measured and they averaged 42μ×26μ. These oocysts resembled those observed, described, and named *Eimeria paulistana* by Da Fonseca (1932). He found them in *Sylvilagus minensis* in Brazil.

Eimeria species. In six cottontails an acute, severe, catarrhal enteritis was present. These rabbits had all been collected from the same farm. In each case smears made of the inflamed mucosa revealed comparatively large, colorless, ovoid oocysts. These organisms differed from any others found by us, or to our knowledge reported from rabbits, in that, they had a conspicuous, bulb-like cap over the micropyle. Twenty of these coccidia were measured and the mean was found to be 32.9μ×22.1μ.

Eimeria media Kessel was not found in any of the 210 rabbits examined. In the records of the Wildlife Disease Laboratory at Iowa State College during 1935–36, however, this parasite is listed as having been taken from a cottontail rabbit.

Order: SARCOSPORIDIA

Sarcocystis cuniculi Brumpt. This protozoan parasite was found in twenty rabbits. The cysts were most numerous in the femoral and lumbar muscles. This species appears to be of little sig-

nificance, other than upon the esthetic sense of the individual dressing infested carcasses for food.

CESTODA

Family: *Taeniidae*

As there is disagreement on the validity of species of tapeworms in North American rabbits, the careful staining technique and close checking of descriptions advocated by Arnold (1938) were followed.

Cysticercus pisiformis Block. The larval stage of the dog tapeworm *Taenia pisiformis* was present in eighty-seven rabbits. With the exception of coccidia this was the most common parasite. The majority of the cottontails harboring it were collected in Story and Hamilton counties (Central Iowa). One rabbit contained over 250 larval cysts, most of them in the body cavities. In this same individual, larval cysts were also removed from the liver, lungs, and kidneys.

Sixty-three rabbits had necrotic, grayish-white foci in their livers. These varied from one to three mm. in diameter. Coccidia were not found in these lesions. We believe that these necrotic foci were caused by immature *Cysticercus pisiformis* as they migrated through the liver before passing into the peritoneal cavity. A small piece of liver containing several necrotic foci was sectioned and stained with hematoxylin-eosin. Following is a histopathologic description of one of the lesions:

The focus is irregular in shape and made up primarily of leucocytes and fibrin. Many of the leucocytes are dead and the various stages of nuclear degeneration (pyknosis, karyorrhexis, and karyolysis) are observed. The margin of the area is surrounded with multinucleated giant cells of varying sizes and shapes. The nuclei of these cells are not arranged around the periphery, as in tuberculosis, but usually are in groups at the poles or at the sides of the cells. In other instances the nuclei are distributed throughout the cell.

There is a definite zone of leucocytic invasion next to the multinucleated giant cells. The staining process does not permit positive differentiation of eosinophiles and pseudo-eosinophiles (polymorphonuclears in rabbits). It appears that most of the leucocytes are pseudo-eosinophiles and lymphocytes. In the zone mentioned there are occasionally large and small multinucleated giant cells. In various places there is evidence of early formation of granulation tissue with the usual fibroblasts and new capillaries.

Adjacent to the zone of leucocytes and granulation tissue are areas of necrosis and hemorrhage. The liver cells are not outlined clearly nor do the nuclei stain distinctly. Areas of marked hyperemia border the zone of leucocytic infiltration. The liver tissue in general shows foci of hemorrhage and hyperemia.

Family: *Anoplocephalidae*

Cittotaenia variabilis Stiles. This tapeworm was recovered from seventy-six rabbits. The favored location was the posterior portion of the small intestine. Infestations varied from one to six parasites. The worms often attained great lengths, some being over thirty cm. This parasite apparently does little harm to the host.

Family: *Taeniidae*

Multiceps serialis Gervais. Becker (1937) in reply to a personal inquiry, stated that a cottontail rabbit with a heavy infestation of the larval stage of *Multiceps serialis* was captured in 1935, near High Point, Iowa. The animal was in good condition and evidenced little or no harmful effects from the parasitism.

TREMATODA

Family: *Hasstilesiidae*

Hasstilesia tricolor Stiles and Hassall. This small fluke was present in eleven cottontails or 5.2 per cent of those examined. Over 10,000 flukes were estimated to have been in the small intestine of one rabbit. The parasite was most commonly found in the first fifty cm. of the small intestine. Large numbers of this fluke were associated with a severe catarrhal enteritis in eight cottontails.

NEMATODA

Family: *Trichuridae*

Trichuris leporis Froelich. This whipworm was found in the caeca of forty-six rabbits or 21.9 per cent of those examined. The heaviest infestation was eight worms and the average approximately three. These worms in such limited numbers apparently cause little injury to the host.

Family: *Trichostrongylidae*

Trichostrongylus calcaratus Ransom. These small nematodes occurred in 44 rabbits. The greatest number in one animal was estimated to be some 4,000. In seven cm. of the small intestine, 460 worms were counted. Due to its small size this parasite is likely to be overlooked except in heavy infestations. These were always associated with extensive catarrhal duodenitis.

Obeliscoides cuniculi Graybill. This stomach worm was present in twenty-five rabbits or 11.9 per cent of those examined. The infections varied from a single worm to fifty-one specimens. This parasite did not appear pathogenic unless present in large numbers. The rabbit containing fifty-one worms showed a mild catarrhal gastritis.

Nematodirus leporis Chandler. Two specimens of this minute nematode were found in the small intestine of one cottontail.

In addition to the parasites listed above, unpublished records (1937) of this laboratory note the finding in an Iowa cottontail of *Dermatoxys veligera* Rudolphi of the family Oxyuridae. This parasite was found in the large intestine and caecum of one rabbit captured in Hamilton County.

SUMMARY

1. Two hundred and ten Iowa cottontails (*Sylvilagus floridanus mearnsi*) were examined for parasites.

2. All rabbits examined, harbored from one to seven species of coccidia, three of which had not previously been reported from North American rabbits.

3. Heavy infestations of the protozoan *Sarcocystis cuniculi*, were found in twenty individuals.

4. Three species of fleas, *Cediopsylla simplex*, *Hoplopsyllus affinis*, and *Ctenocephalides canis*, and one species of tick, *Haemaphysalis leporis-palustris* were identified.

5. The tapeworm, *Cittotaenia variabilis*, was found in seventy-six of the animals necropsied.

6. Eighty-seven cottontails were infested with the larval stage of *Taenia pisiformis*.

7. The trematode, *Hasstilesia tricolor*, was found in eleven rabbits.

8. Four species of nematodes were recorded: namely, *Trichuris leporis*, *Trichostrongylus calcaratus*, *Obeliscoides cuniculi*, and *Nematodirus leporis*.

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THE FOOD HABITS OF THE RING-NECKED PHEASANT IN MINNESOTA[1]

Louis A. Fried

The heavy population density that the ring-necked pheasant, *Phasianus colchicus torquatus* (Gmelin), has attained in some parts of Minnesota has made it the most important upland game bird, but its numbers and feeding habits have aroused the concern of farmers and truck gardeners. Chief damages reported are to newly planted or sprouting corn, small grains, potatoes, and in mid-summer to such succulents as melons and tomatoes.

Complaints of severe damage to corn by pheasants were especially numerous during the spring of 1935. Cold, wet weather that year delayed germination, and as a consequence damage by almost all enemies of planted corn was increased. Corn root-rot, cutworms, wireworms, blackbirds, crows, and rodents all took their toll, so that in many instances replantings were necessary. Because of the wet condition of the ground, corn planting was not completed in some counties until well past the middle of June.

The pheasant was blamed for much of the damage to corn actually done by less conspicuous and less easily observed enemies, and since its economic status had become controversial, the University of Minnesota and the State Division of Game and Fish decided to conduct a cooperative investigation into feeding habits by analysis of crop and gizzard contents.

Details of the joint study were worked out by Ralph T. King, now director of the Roosevelt Wildlife Forest Experiment Station and Dr. Gustav A. Swanson, at that time State Biologist. Game wardens were to collect birds by shooting in every section of the state and especially in those areas where damage to crops was being reported. The birds, taken before 10 o'clock in the morning and after 4 o'clock in the afternoon in order to insure full crops, were sent to the Wildlife Laboratory at University Farm for crop and gizzard analyses.

Of the 515 birds collected from June 1935 to July 1938, 106 were picked up dead during January, February, and March of 1936, when winter conditions were the most severe they had been for many years. There was one period of six weeks in which the daily temperature was zero or below, with severe blizzards and much snow. Thirty-three of the 106 birds picked up dead had no food in either crop or gizzard and of these 12 appeared so emaciated that there was little doubt as to the cause of death. Subsequent post-morten examinations by Dr. R. Fenstermacher of the Veterinary Division confirmed starvation as the cause of death. External examination of the remaining 73 birds showed them to be in good flesh. Many, however, had ice over the eyes or in the mouth and gullet in ad-

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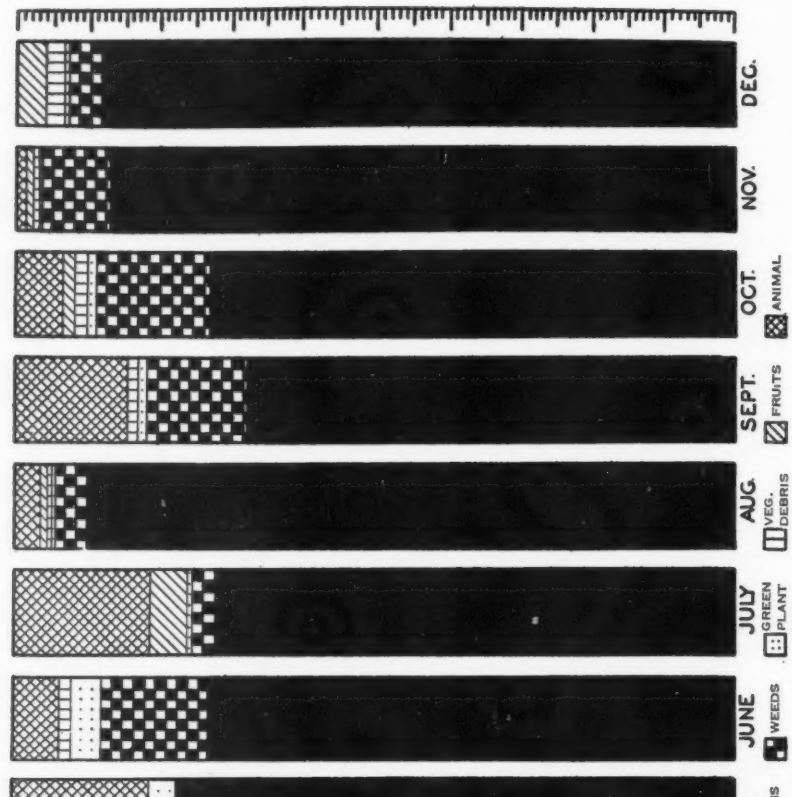

Fig. 1. The percentage composition by volume of the food of pheasants

dition to heavy coatings of ice on the rump and on or under the wings. Internal examination revealed in most cases a good subcutaneous layer of fat, an enlarged heart and hemorrhages into the pericardium. Such findings indicate the strong possibility that these birds died of exposure and exertion rather than of starvation. Green and Beed (1936) reported on the severe winter conditions in early 1936, in Iowa, as they affected pheasants and quail, and found that the greatest mortality among the birds was caused by freezing and choking or a combination of both and not by predation or starvation. These workers reported that "the rate of mortality in pheasants was directly proportional to the distance from good protective cover." Green (1938) wrote a more detailed account of the winter survival of the ring-necked pheasant in northern Iowa and stated that "losses were highest in flocks that roosted in open cover and that were forced to range some distance in feeding."

The writer's findings and conclusions for Minnesota are in complete agreement with the observations of the Iowa investigators as to the causes of death among pheasants in the severe winter of 1935–36.

Included also in the present paper are data on the crop and gizzard contents of 144 pheasants collected during the summer of 1932 and analyzed by Dr. L. J. Bennett. The results of his examinations were given in number of individuals instead of by volume which made a transposition necessary. This, however, was easy to do for in the writer's work, individuals of a species of plant or animal food were always counted and measured in a graduated cylinder. Quantities were measured in moist condition and percentages were computed on the volumetric basis.

The percentages given in the tables and mentioned in the text are computed from crop contents only, for food remains in the crop but a comparatively short time and is little changed from its original condition. In the gizzard, on the other hand, food is ground up and the softer elements such as insect larvae and fruits soon become unidentifiable while a large part of the harder seeds and the more heavily chitinized insect parts remain for an indefinite time. The gizzard contents, therefore, were not included in any quantitative deductions for they tended to increase unduly the representation of the harder types of food; their analysis, however, serves to throw much additional light on the variety of food species eaten.

FOOD

Crop analysis shows that vegetable matter is predominant in the diet of Minnesota pheasants at all times of the year. It forms at least $\frac{2}{3}$ of the food taken in every month of the year and represents 96.0% of the total annual intake. Animal matter, on the other hand, is taken in very small amounts even at times of the year when it is abundant. It forms only 3.99% of the total subsistence. The amount of animal food is comparatively large in May (See Table 1) because several birds had fed almost exclusively on snails.

Cultivated Grains. Relative percentages of important foods eaten by pheasants are shown in Table 1, and represented graphically in Fig. 1. Cultivated grains it will be seen form the major

TABLE 1
FOODS EATEN BY 659 MINNESOTA PHEASANTS

Month	Birds examined	Grains	Weed seeds	Green plant material	Vegetable debris	Fruits	Snails	Insects
January	35	95.55	.34	—	.49	3.62	—	—
February	88	77.24	2.38	11.17	1.17	8.04	—	—
March	30	90.67	1.36	—	1.44	6.53	—	—
April	46	88.38	1.83	2.32	1.35	.87	.75	4.50
May	18	76.17	—	5.08	—	—	18.75	Trace
June	62	72.97	14.83	4.24	1.62	—	Trace	6.34
July	124	72.67	3.10	.61	—	5.11	Trace	18.51
August	51	88.62	5.70	.61	.78	.95	Trace	3.34
September	52	67.71	11.64	1.32	1.44	—	Trace	15.51
October	58	76.43	16.76	1.20	1.80	1.45	—	6.46
November	64	86.98	9.79	.55	.73	.77	—	1.18
December	31	88.23	4.58	.50	2.49	4.20	—	—
Percentage of total food		81.3	6.1	1.3	3.6	3.8	.2	3.7

portion of the food in every month of the year. Pheasants eat the largest amounts of cultivated grains in the winter months when other foods are hard to find. Even during the summer months when insects are available and abundant, grains form the bulk of the diet.

Cultivated grains made up 81.3% of the total annual food. Thus, the pheasant is strictly a farm bird for it depends chiefly upon agriculture to supply the food that it prefers.

Corn was important in nearly every month of the year; in seven months it exceeded all other foods combined, and for the entire year it averaged 49.5% of all foods taken. It is the most important single item in the pheasant's diet and is the preferred food at all times of the year. Investigators working on the food habits of the ring-necked pheasant in other states also have reported that corn is by far the most favored food.

Thus, Swenk (1930) found that corn made up 67% of the year's food in Nebraska. In South Dakota, Severin (1933) wrote that 46.7% of the pheasants takens during 12 months of the year had corn in their crops. Gigstead (1937) studying the food habits of pheasants in Wisconsin showed that corn made up 58.8% of the food taken in October and November. Dalke (1937) noted that corn comprised 33% of the year's food of pheasants studied in Michigan. Leffingwell (1928) found that corn was the favorite food of pheasants in New York State. In Pennsylvania, Bennett and English (1939) analyzed the crop contents of 423 pheasants taken during the hunting season (October 28, 1938 to November 26, 1938) and reported that corn made up 54% of the total volume of food.

The largest quantity of corn was consumed by Minnesota pheasants in November (84.22%) and the smallest amount in July (0.91%) when the plant is in the actively growing stage. In December, 76.96% of the food was corn but in January, the quantity eaten,

dropped to 28.88%. This reduction was unexpected as it was commonly believed that corn was taken in large quantities in mid-winter. The result, however, agrees with those published for the ring-necked pheasants in Wisconsin and Michigan. On the other hand, Severin (1933) and Swenk (1930) working with these birds in South Dakota and Nebraska, respectively, found corn taken in the largest amount in January. While climatic conditions such as wind, snow, and extreme cold may in part explain this difference in results, they do not account for it entirely, because other factors such as winter feeding and local farm practices in harvesting or feeding corn to stock, may also be concerned.

From February to June, the proportion of corn consumed averaged 60.63%, while in June the corn eaten amounted to 57.18%. The June figure seems surprisingly high because of the increased availability of insect food and because of the comparative unavailability of corn then usually well into the growing period.

The studies of Dalke (1937), Severin, and Swenk show that corn consumption in June is relatively low and that of insects increased. The difference in the present author's results is due chiefly to the fact that the birds were collected in June of a year, 1935, when spring was particularly cold and wet so that crop plantings were not only made late in the season but were also repeated several times because of floodings. In many places, especially in the areas where most of the June birds were collected, corn was still being planted well past the middle of the month.

There was enough corn left exposed so that there was little need for the birds to dig it up. These conditions made more corn available than usual and pheasants were able to get all they desired.

Kernels of corn eaten by pheasants were classified into four categories, namely, perfect, multilated, silage, and sprouted. Mutilated corn is that already gnawed by rodents and is easily recognized. Silage corn being more or less discolored is also easily identified. The percentages in Table 2 show that pheasants do not damage corn to the extent commonly believed.

Only 5.8% of the corn eaten in June could be identified as sprouted. Sixty and six-tenths percent of the corn consumed by pheasants in that month was either already multilated by rodents or had been fermented (silage) and only 33.6% was perfect; most of this may have been waste corn. In May and June, when pheasants are commonly believed to do their greatest damage to corn, the amount of mutilated and silage corn together exceeded by about 24.4% that of perfect corn. Sprouted grains are but 0.5% of the corn annually eaten.

Hicks (1936) says, "the actual damage to sprouting corn is considerably less than commonly believed. The pheasant has 'inherited' the blame for seed losses formerly assigned to crows, cutworms, and various rodents." Gigstead (1937) investigating reported corn damage by pheasants in certain Wisconsin areas found blackbirds, gray squirrels, and pocket gophers to be the chief agents of destruction. He says, "In most complaints over damage to corn during the planting season, there were found to be other reasons why the

TABLE 2

CONDITION OF CORN EATEN BY MINNESOTA PHEASANTS

Month	Birds examined	Percentage of total food composed of corn	Perfect	Mutilated	Silage	Sprouted
January	35	28.88	97.0%	3.0%	—	—
February	88	47.70	90.2%	6.9%	—	—
March	30	67.12	92.3%	1.8%	—	—
April	46	63.80	48.9%	12.2%	—	—
May	18	67.90	51.3%	48.7%	—	—
June	62	57.18	33.6%	28.1%	32.5%	5.8%
July	124	0.91	100.0%	—	—	—
August	51	6.47	83.3%	16.7%	—	—
September	52	21.96	50.6%	49.4%	—	—
October	58	62.44	76.6%	20.4%	3.0%	—
November	64	84.22	75.3%	17.0%	7.7%	—
December	31	76.96	88.3%	11.4%	.3%	—
Percentage of total corn			78.4	14.1	7.0	.5

corn did not come up." Severin reports only 4 kernels of corn definitely sprouted and 26 questionably sprouted out of a total of 949 kernels of corn found in the crops of 71 birds taken in South Dakota during May and June.

Swenk says that while most of the corn eaten in Nebraska in May and June was unsprouted, nevertheless there was plenty of evidence that pheasants did pull newly sprouted corn. According to Cottam (1929) the pheasant does as much good to agriculture as harm. Burnett (1921) examined the crop contents of pheasants in Colorado and found that the corn-pulling habit resulted in heavy damage where the birds were numerous. Dalke, who studied the crop contents of 352 Michigan pheasants, says that, "the chief source of all the corn eaten, however, is field waste, and in the spring the source of this corn is often from manured fields."

Next to corn—oats, barley and wheat were taken in largest amounts and formed 13.6%, 8.8%, and 6.6%, respectively, of the total food. Together, they made up 71.61%, 79.08% and 46.46% of the food eaten in July, August, and September, being taken in largest quantities then because much waste grain is left strewn about the fields as a result of harvesting operations.

Black amber cane, eaten only sparingly in most months of the year, was taken in the largest amounts in December (6%) and in January (12.5%). Eleven birds or 1.67% of the 659 examined had this grain in their crops. Of the total food eaten, seeds of black amber cane comprised only 1.85%.

These results, however, do not prove that black amber cane is not a valuable winter food. Game birds must learn to eat new foods and it may be that pheasants do not as yet recognize the kernels of black amber cane as desirable food. It is also true that even though the Minnesota Game and Fish Department was instrumental in the planting of a total of about 15,000 acres of this grain for food patches in 1935, 1936, 1937, and 1938, such foods as corn,

wheat, barley, and oats were far more abundant.

Weed Seeds. Weed seeds, which made up 6.14% of the total volume of food, were taken in every month except May. During January, February, March, and April only very small quantities were used. In June, however, weed seeds made up 14.83% of the month's food but this relatively high amount was due to the fact that two of the birds examined had eaten unusually large quantities of green foxtail seeds. Beginning in July with 3.10%, the quantity of weed seeds taken rose gradually until in October it formed 16.76% of the food.

The seeds of foxtails (green and yellow) and common ragweed made up the bulk of the weed seeds eaten (74%) and formed 4.54% of the total annual food. The largest quantities of these seeds were taken during September, October, and November. Foxtails contributed nearly half of all the weed seeds eaten, no doubt, because they produce more seed and are more widely distributed than any other weeds.

Common ragweed achenes were consumed in largest amounts in October, November, and December. In October, they formed 6.06% of the month's food and in November and December, 3.2% and 3.9%, respectively. Less than half of one per cent in monthly average was eaten from January through April and none at all from May through September. These achenes make up 1.5% of the total annual food and 24.5% of all the weed seeds. Next to green foxtail, common ragweed was the weed seed found in largest amounts.

Black bindweed or wild buckwheat, though relatively common, was taken frequently but in small amounts and only in July and November was the quantity more than a trace. It formed only 0.3% of the total food of the year and 4.6% of all the weed seeds eaten. Other smartweeds were taken in very small quantities and are, therefore, of minor importance in the varied diet of the pheasant. Other weed seeds, in the aggregate, made up 1.3% of the total food.

Fruits, Berries, and Miscellaneous Plant Material. Fruits and berries formed 3.8% of the yearly food and were taken in the largest proportions during December (4.2%), January (3.6%), February (8.0%), and March (6.5%), indicating that they may serve as emergency foods. In July, fruits and berries made up 5.1% of the month's food, while in October and November when they are far more abundant they formed only 1.45% and .77% respectively. It is probable that they serve as a source of moisture in July.

Wolfberry (*Symphoricarpos*) was the major fruit eaten; it comprised 55.5% of all fruits eaten during the year and 2.1% of the total food. It was taken most often in February and March. Other fruits and berries identified included those of rose, grape, raspberry, strawberry, hawthorn, ground cherry, horse nettle, black nightshade, chokecherry, wild red cherry, smooth sumac, Russian olive, and poison ivy. Acorns also were noted.

Green plant material made up 1.3% of the total food. That taken in February was dry alfalfa upon which the birds picked up dead had been feeding. The largest amounts of foliage were taken in April, May, and June. The bulk of this food consisted of sweet

clover and alfalfa, but blue grass, quack grass, and leaves of dandelion and wild mustard also were taken.

Various bits of plant material and fruit pulp not easily identified, and recorded as vegetable debris formed 3.6% of the total annual food.

Two instances were found in which pheasants had been budding. In the one case, the crop was filled with American elm buds, taken in February and in the other, the crop contained poplar catkins, eaten in May. Thus, pheasants may sometimes resort to budding even though they are possibly not equipped physiologically to live upon such food for any length of time.

Animal Matter. Animal matter, of which insects formed the most important part, made up only 3.9% of the total food. The large proportion of animal matter taken in May (18.75%) consisted chiefly of two kinds of snails, namely, *Succinea* sp. and *Stagnicola* sp. Snails were also eaten in April, June, July, August, and September. Snails are a ready source of calcium which is required in larger amounts at egg-laying time.

Other animal food eaten by pheasants and of minor importance consisted chiefly of earthworms, spiders, and millipeds. Most of the animal matter was taken in June, July, September. and October when insects are abundant. The greatest variety was eaten in September.

Orthoptera, Coleoptera, and lepidopterous larvae formed the bulk of the animal food. Other orders of insects, such as the Hymenoptera, Hemiptera, Homoptera, and Diptera also were represented in the animal food of the pheasant but they were taken in such small quantities that they are not considered important items in the diet.

Orthoptera were consumed in greater quantity and numbers than insects of any other order. They formed the bulk of the animal food in April and from July through November. While they composed only 2.9% of the total food, they made up 74.3% of the animal food. The greatest quantity and number of individuals of Orthoptera were consumed in July. This is important, as tending to prevent grasshoppers from doing immediate damage to growing crops and also from reproducing.

Melanoplus femur-rubrum was taken more often and in greater numbers than any other species of grasshopper. One October bird had eaten 72 while another bird collected in July had consumed 40.

Coleoptera were taken in largest proportions in June and September when they formed 50.8% and 15.5% respectively, of the insect food. Most of the Coleoptera in June crops were the injurious May beetles (Phyllophaga) while the bulk of those in September birds were beneficial ground beetles (Carabidae). Wireworms (Elateridae) were taken sparingly. Lepidoptera were eaten in largest amounts in June and August when they made up 49.0% and 16.7%, respectively, of the insect food. These consisted almost entirely of six species of injurious cutworms (Noctuidae). Coleoptera and Lepidoptera together made up 0.7% of the total food and 18.7% of the insect food.

There were 234 species of foods identified of which 126 were plants and 108, animals. The ten items found most frequently were: corn, in 41.9% of the birds, foxtail grasses (33.8%), grass-

hoppers and crickets (32.4%), beetles (26.8%), cultivated oats (21.4%), wild rose (21.4%), black bindweed (21.4%), barley (20.8%), common ragweed (16.2%), and wheat in 15.8%.

Plant and animal foods eaten by Minnesota pheasants.

	Percentage by volume	*Percentage of occurrence*
Cultivated grains	81.3	72.5
Weed seeds	6.1	61.1
Animal matter	3.9	38.5
Fruits	3.8	36.5

Plant foods most important by volume.

	Percentage by volume
1. Corn (*Zea mays*)	49.5
2. Cultivated oats (*Avena sativa*)	13.2
3. Barley (*Hordeum vulgare*)	8.8
4. Wheat (*Triticum aestivum*)	6.6
5. Green foxtail (*Setaria viridis*) }	3.0
6. Yellow foxtail (*Setaria glauca*) }	
7. Alfalfa (*Medicago sativa*)	2.4
8. Wolfberry (*Symphoricarpos occidentalis*)	2.1
9. Black amber cane (*Andropogon sorghum*)	1.8
10. Common ragweed (*Ambrosia artemisiaefolia*)	1.5
11. Chokecherry (*Prunus virginiana*)	1.3
12. Wild prairie rose (*Rosa blanda*)	0.7
13. Common flax (*Linum usitatissimum*)	0.58
14. Rye (*Secale cereale*)	0.4
15. Smooth sumac (*Rhus glabra*)	0.35
16. European millet (*Panicum miliaceum*)	0.27
17. Russian olive (*Elaeagnus angustifolia*)	0.25

CONCLUSIONS

1. In Minnesota the ring-necked pheasant is chiefly a granivorous bird, preferring cultivated grains at all times of the year.

2. Corn is taken more often and in greater quantity than any other single kind of food, and is the most important item in the pheasant's diet.

3. Damage to newly planted and growing corn by the pheasant has been greatly exaggerated; less than one per cent of the corn eaten is sprouted.

4. In May and June, when pheasants are believed to do their greatest damage to corn, the amount of mutilated and silage corn together exceeded by 24.4% the amount of perfect corn.

5. While winter feeding probably saved many pheasants from starvation, the high mortality during the winter of 1936 was due more to lack of good cover than to want of food. Proper shelter is at least as important a factor in saving birds during periods of severe weather as is food. In some cases it is the decisive factor.

6. Pheasants consume a large number of weed seeds but the effect upon the next year's crop of weeds is probably small.

7. The most common weed seeds taken were those of green and yellow foxtails, common ragweed, and wild buckwheat. Together, these made 78.7% of all weed seeds eaten.

8. Grasshoppers were eaten more often and in greater numbers than any other kind of animal food. The largest proportions of these insects were taken in April and in July when they were in the egg and nymphal stages, respectively. Thus, pheasants may act as a check not only on the immediate damage to growing crops but also on future grasshopper populations.

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LIFE HISTORY NOTES ON THE BANNER-TAILED KANGAROO RAT, MERRIAM'S KANGAROO RAT, AND THE WHITE-THROATED WOOD RAT IN ARIZONA AND NEW MEXICO

Gale Monson and Wayne Kessler

During the period March 1935 to August 1936, inclusive, the writers gathered a quantity of miscellaneous information concerning the banner-tailed kangaroo rat, *Dipodomys s. spectabilis* (Merriam), Merriam's kangaroo rat, *Dipodomys m. merriami* (Mearns), and the white-throated wood rat, *Neotoma a. albigula* (Hartley) in southeastern Arizona and southwestern New Mexico. Field work was confined to the Lower Sonoran Zone, principally in the San Simon Valley in Arizona and on the Lordsburg Plains in New Mexico, and consisted chiefly of den excavations and population surveys. A mass of more or less related data was gathered on the three species during the course of biological activities for the Soil Conservation Service, United States Department of Agriculture. The more salient findings are here presented.

We are indebted to various members of the Service then stationed at Safford, Arizona, for their assistance; also to A. E. Borell, Lawrence V. Compton, Dr. Walter P. Taylor, and Dr. Charles T. Vorhies, for criticisms of the manuscript. The authors made their own identifications of plants and plant parts but questionable material was checked with Dr. J. J. Thornber of the University of Arizona.

Banner-tailed Kangaroo Rat

Vorhies and Taylor (1922) published a life history of the banner-tailed kangaroo rat. The present paper does not repeat information they have already given, but rather offers data in most respects new. Since the vegetation and climate of the region covered by the Vorhies and Taylor study differ from those of the area involved in the present investigation, it is to be expected that results would differ somewhat, particularly those concerning food habits.

The distribution of the banner-tail includes the entire area outlined in the introduction, but occurrence is spotty and there are large areas from which the rodent is absent. Populations denser than one den per acre are confined principally to small colonies averaging one to five acres in extent. The densest population was found on the Lordsburg Plains in the vicinities of Red Rock and Lordsburg, New Mexico, where aggregegations of dens in some instances formed colonies several miles in diameter.

Dens were ordinarily constructed in open locations, but advantage was frequently taken of protection offered by mesquite (*Prosopis glandulosa*), creosote bush (*Larrea tridentata*), squawberry (*Lycium parviflorum*), and other desert shrubs. A correlation seems to exist between the presence of banner-tails and the type of vegetation. Generally speaking, it may be said that they prefer a mixed grass-shrub type; are seldom found in areas of pure grass, or in areas

devoid of grass; and particularly favor areas where a good stand of annual forbs is present during the spring, and of annual grasses during the late summer.

Seventy banner-tail dens were excavated during a 12-month period as follows: June, 2; July, 5; August, 3; September, 5; October, 5; November, 26; December, 5; January, 3; February, 4; March, 6; April, 4; and May, 2. Although each den gave every indication of being occupied, only 44 contained banner-tails. It is difficult to explain why they were not found in the other 26; perhaps the best explanation is that the occupant merely was not at home or was in some passageway overlooked during excavation. Usually only one banner-tail was found in each of the occupied dens, corroborating the findings of Vorhies and Taylor (1922, p. 36). In one den, an adult female and an adult male were found; in another 2 adult females; in a third, 2 adult males. Other kinds of animals were present in several dens. In den No. 1 were found one banner-tail, one wood rat, one king snake (*Lampropeltis getulus*), and 4 unidentified lizards; in den No. 15, 2 banner-tails, one Merriam's kangaroo rat, and one desert brush-tailed pocket mouse (*Perognathus penicillatus eremicus*); in No. 21, one banner-tail, one king snake, one unidentified lizard, and one unidentified toad; in each of Nos. 38 and 50, one banner-tail and 2 rattlesnakes (*Crotalus* sp.). No young banner-tails were found.

Since the banner-tail makes a practice of storing large quantities of food in its den, its diet may be determined by examining the stores. Records were kept of the kinds and quantities of food stored in 64 of the excavated dens (6 held no caches). Stored material was measured by means of a container of known capacity, into which the food was placed just as found in the den. Frequently a considerable amount of fine soil was interspersed in the stores, which would have made weighing of the food materials difficult. In measuring the caches, the percentage by species sometimes had to be estimated, since, where two or more kinds of seeds were mixed, their separation would have been an almost interminable task. Such estimation was usually unnecessary, however, as the bulk of each cache was ordinarily composed of a single plant species. The seeds of annual gramas, however, were generally mixed, and for that reason they were treated as one species.

An analysis of the storage contents is presented in the subjoined table. This is arranged on the basis of the total storage of one den as 100 units, with a total of 6,400 units for the 64 dens. Thus, 50 per cent storage of annual grama in one den would represent 50 units in that den by volume.

Of the 6,400 total units, 4,681 or 73.14 per cent consisted of grass storage, of which 59.72 per cent was composed of annuals and 13.42 per cent of perennials. Plants other than grasses were represented by 1,494 units or 23.34 per cent. Of this classification, 15.16 per cent was from annuals and 8.18 per cent from perennials. Considering all storage, 74.88 per cent was from annual, and only 21.60 per cent from perennial plants. The total identified storage represented 6,175 units of the 6,400 total, or 96.48 per cent. The remaining 225 units or 3.52 per cent represented

material not large enough in bulk to be reckoned with, and undetermined items.

Each plant that contributed more than one per cent to the total storage has been listed in Table 1. Smaller amounts of the following grasses were found: Poverty three-awn (*Aristida divaricata*) spidergrass (*Aristida ternipes*), sandbur (*Cenchrus echinatus*), fingergrass (*Chloris elegans*), six-weeks fescue (*Festuca octoflora*), tobosa (*Hilaria mutica*), *Panicum* spp., spike pappusgrass (*Pappophorum wrightii*), burro grass (*Scleropogon brevifolius*), plains bristlegrass (*Setaria macrostachya*), and sacaton (*Sporobolus wrightii*). Non-grasses each contributing less than one per cent to the total storage were: Catclaw (*Acacia greggii*), tumbleweed (*Amaranthus graezicans*), aster (*Aster* sp.), salt bush (*Atriplex* sp.), *Baileya multiradiata*, *Caucalus microspermus*, *Chaenactis* sp.,

TABLE 1

FOOD OF THE BANNER-TAILED KANGAROO RAT AS DETERMINED BY MEASUREMENT OF CACHES FROM 64 DENS

Species	Percentages		
	Annuals	Perennials	Totals
Grasses:			
Annual grama (*Bouteloua aristidoides*)	47.70		
Annual grama (*Bouteloua barbata*)			
Rothrock grama (*Bouteloua rothrockii*)		9.97	
Six-weeks three-awn (*Aristida adscensionis*)	9.80		
Fluffgrass (*Triodia pulchella*)		1.73	
Annual eragrostis (*Eragrostis arida*)	1.30		
Other grasses (each species less than 1% of the total stored material)	.92	1.72	
Total grasses	59.72	13.42	73.14
Other plants:			
Milk vetch (*Astragalus nuttallianus*)	2.86		
Snakeweed (*Gutierrezia sarothrae*)		2.67	
Bladderpod (*Lesquerella gordoni*)	2.50		
Lotus trispermus	2.25		
Careless weed (*Amaranthus palmeri*)	1.63		
Filaree (*Erodium cicutarium*)	1.52		
California poppy (*Eschscholtzia mexicana*)	1.44		
Dock (*Rumex hymenosepalus*)		1.41	
Pepper-grass (*Lepidium medium*)	1.37		
Other non-grasses (each species less than 1% of the total stored material)	1.59	4.10	
Total non-grasses	15.16	8.18	23.34
Total annual species	74.88		
Total perennial species		21.60	
Amounts not large enough to be reckoned, and undetermined material, combined			3.52
GRAND TOTAL			100.00

Cladothrix sp., *Cogswellia* sp., *Croton texensis*, Mormon tea (*Ephedra* sp.), fleabane (*Erigeron* sp.), wild buckwheat (*Eriogonum* sp.), spurge (*Euphorbia albomarginata*), *Haplopappus hartwegi*, *Hoffmanseggia densiflora*, Colorado rubber plant (*Hymenoxys odorata*), unicorn plant (*Martynia altheaefolia*), evening primrose (*Oenothera* sp.), staghorn cholla (*Opuntia versicolor*), limoncillo (*Pectis papposa*), desert holly (*Perezia nana*) fiddleneck (*Phacelia crenulata*), Indian wheat (*Plantago ignota*), mesquite (*Prosopis glandulosa*), ragwort (*Senecio* sp.), sleepy catchfly (*Silene antirrhina*), trompillo (*Solanum eleagnifolium*), false mallow (*Sphaeralcea* sp.), and burnut (*Tribulus terrestris*).

An unequal number of dens was excavated each month. It would perhaps have been preferable to excavate the same number each month, but a variety of circumstances precluded this action. In analyzing the effect of season upon the character of den storage, annual grasses were found more commonly during and after the late summer growing season, and annual forbs (non-grasses) during and after the spring growing season. More seeds seem to be gathered during and after the late summer growing season, since larger stores were found then. To obtain an accurate picture of the food habits, more dens would have to be excavated from August to April than during the remainder of the year. Storing activity is most slack during the winter months. Also, a good deal of old material was found that would tend to counterbalance inequalities. On the whole, it is felt that the data represent nearly an average of the year-round food habits of the banner-tail.

MERRIAM'S KANGAROO RAT

Merriam's kangaroo rat is a common inhabitant of most of the area considered. Roughly, it may be said that the animal's range is coincident with that of the creosote bush. The rodent is found in greatest numbers in more or less open creosote-bush country possessing a fair to good growth of annuals, such as the territory between the Gila River and the Gila Mountains in Arizona, or in areas of loose soil, especially the small flood plains along the San Simon Wash, where there is excellent annual cover and small shrubs such as salt bushes (*Atriplex* spp.) or snakeweed.

An attempt was made to determine the density of population by making acre den counts. Thirty-three one-acre plots were marked off in various localities, and Merriam's kangaroo rat dens therein counted. Dens per acre ranged from 8 to 53, with an average of 31.3 (there was a total of 1,033 dens in the 33 acres counted). These counts were made where the rodents were considered common to abundant. However, one den does not mean one rodent, or a pair. In 74 den excavations, only 18, or 24 per cent, yielded Merriam's kangaroo rats and in no instance was more than one individual found per den. These figures indicate an average of one inhabitant per 4.11 dens. This estimate, however, may be inaccurate because some dens were not definitely known to be Merriam's kangaroo rat dens, and in other instances it is possible that part of the den was overlooked in excavation. Nevertheless, the ratio was the most accurate the writers could obtain.

The dens of this kangaroo rat are

simple, consisting of a series of connecting underground tunnels having one to several openings. In contrast to the large mounds of the banner-tailed kangaroo rat, little soil is piled up in the process of construction. The dens are almost invariably made among the roots of such shrubs as creosote bush, mesquite, catclaw, or salt bushes. Short passageways are frequently dug underneath a small shrub or in the open. These are apparently for temporary or emergency protection rather than for regular use. At the end of one of the tunnels in each den is ordinarily found a nest consisting largely of annual grama grass. One nest was constructed partially of feathers.

This rodent tends to live in colonies, ranging in size from a half dozen to several hundred dens. This gregarious tendency is especially noticeable when traversing a homogeneous stretch of soil and vegetation, where one may pass from territory marked by great activity on the part of these rodents directly into an area where they are absent. In places where they are abundant, where the soil is loose and receptive to trail-markings, and where no obliterating rain has fallen for some time, their trails connecting dens and passageways indicate an extraordinary degree of activity.

It is difficult to obtain data regarding the food habits of Merriam's kangaroo rat, since it does not ordinarily store food. It masticates its food so thoroughly that stomach analyses failed to contribute any material knowledge. (This was also true of the banner-tailed kangaroo rat.) Examination of the cheek pouches of trapped or captured individuals seems to be the only dependable method of procuring data.

Seven instances of den storage were found, consisting in each case of the seeds of annual gramas and snakeweed. The annual grama seed was composed of ripe, dry spikelets in amounts ranging from a trace to 3 quarts, and the snakeweed material of dry seed heads in amounts from a trace to a half pint. Vorhies and Taylor (1922, p. 33) record no den storage by Merriam's kangaroo rat.

Frequently stomach contents were partially of a greenish color, indicating that this rodent turns to fresh green annual grasses or weeds for part of its diet. In most stomachs examined, unidentified roundworms were found, usually about 4 in number and 3 to 4 cm. in length. It is interesting to note that whereas Merriam's kangaroo rat was usually parasitized by roundworms, the banner-tails examined yielded none.

Cheek pouches of trapped specimens were usually partially or completely filled with the barley bait, but often contained other food. These pouch examinations were made largely late in winter and early in spring and revealed a wide variety of food selection. Plant seeds found consistently were those of six-weeks fescue, annual gramas, creosote bush, Indian plantain, and *Lotus* spp. This rodent's diet is largely dry seeds of annuals, and it shows little preference for any one species, apparently taking any available.

WHITE-THROATED WOOD RAT

The white-throated wood rat (or, as it is more commonly known in the Southwest, pack rat) inhabits all of the area considered, ranging throughout a variety of environmental conditions. It

is least common in grassy stretches and in pure creosote bush stands, and is abundant in browse country vegetated by such species as mesquite, catclaws (*Acacia greggii* and *A. constricta*), soapweed (*Yucca elata*), Spanish dagger (*Yucca macrocarpa*), prickly pears (*Opuntia engelmannii* and *O. macrocentra*), and staghorn cholla (*Opuntia versicolor*). These plants offer the wood rat food, and protection for its dens. Counts of dens and den openings showed that mesquite was first in preference as a building shelter, followed by staghorn cholla, prickly pear, catclaws, and soapweed.

In an area where wood rats were considered common, their dens were counted on a 750-acre tract, 1,927 being found. Of these, 167 or 8.6 per cent were unoccupied. Thus there were 2.3 occupied wood rat dens per acre in a country where banner-tailed kangaroo rats, Merriam's kangaroo rats, and antelope ground squirrels (*Citellus h. harrisi*) also were common.

Eighty-two wood rat dens were opened by the writers over a 12-month period, mostly in July and August. Twenty-six were found to be unoccupied. Occupied dens usually contained a single individual. Females accompanied by young were found in 4 instances once in May (2 half-grown young), once in June (3 half-grown young), and twice in July (one with 2 fetuses, one with 2 small young).

Plants found in den stores, and plant remnants scattered in the dens, represented 51 identified species: Allthorn (*Koeberlinia spinosa*), annual gramas, barrel cactus (*Ferocactus* sp.), bladderpod, *Boerhaavia* sp., borage (*Pectocarya* sp.), California poppy, careless weed, catclaws, *Chaenactis* sp., cotton-top (*Trichachne californica*), creosote bush, dock, *Encelia* sp., false honeysuckle (*Anisacanthus thurberi*), false mallow, fiddle-neck, filaree, *Franseria* sp., *Haplopappus hartwegi*, *Heugilia* sp., *Hoffmanseggia densiflora*, lambs-quarters (*Chenopodium* sp.), *Lotus trispermus*, lupine (*Lupinus* sp.), mesquite, tangle grass (*Muhlenbergia porteri*), milk vetch, Mormon tea, paloverde (*Parkinsonia torreyana*), pepper-grass, prickly-pears, ragwort, Rothrock grama, senna (*Cassia covesii*), six-weeks fescue, soapweed, sotol (*Dasylirion wheeleri*), Spanish dagger, spurge, squawberry, staghorn cholla, side-oats grama (*Bouteloua curtipendula*), *Thelypodium* sp., tobosa, trompillo, and *Ximenesia exauriculata*. Of these, mesquite, staghorn cholla, prickly-pears, catclaws, and soapweed were most frequent. In the case of the mesquite and catclaw, empty seed pods were usually found. The beans were apparently removed and eaten as the pods were gathered. Flowers and leaves of mesquite and catclaws were frequently found, and many mesquites had been partially stripped of their bark. In the case of the cholla and prickly pears, the flowers and fruits were eaten, as well as portions of the stems. Soapweed leaves, seeds, and roots were consumed by the wood rats.

Small annual plants (especially *Lotus trispermus*, milk vetch, pepper-grass, and limoncillo) were often stored in quantities as great as half a bushel. Grasses apparently form a minor part of the wood rat's diet, as they were found in stores in only a few instances.

ECONOMIC CONSIDERATIONS

The three species discussed are the

most common rodents in much of the range country of southeastern Arizona and southwestern New Mexico. On account of their abundance and their presumably harmful food habits, they have been subjected to more or less frequent control campaigns. According to the findings incorporated in this paper, both the banner-tailed and Merriam's kangaroo rats subsist largely on the seeds of annual plants. These plants produce such prolific crops of seed that it seems unlikely that even an abundance of kangaroo rats could materially alter their reproduction. The fact that kangaroo rats take mostly the seeds—not the foliage—of the annual forage available to domestic animals means that on a range comprised largely of annual and shrubby vegetation these rodents offer slight competition to grazing livestock.

The present work tends to bear out the thesis of Taylor, Vorhies, and Lister (1935) that the presence in numbers of some rodents is more the result than the cause of overgrazing. Seemingly overgrazing, which tends to increase the relative proportion of annual grasses and weedy vegetation—favored foods of the rodents—aids in building up populations of these animals.

The evidence, however, is by no means conclusive and more information is needed. The present work was carried out on more or less overgrazed ranges where annuals were the dominant plants, hence did not disclose what kangaroo rats would eat in an area dominated by perennial grasses. The writers, however, failed to find any great number of kangaroo rats where perennial grasses were dominant and this observation would *indicate* that, by and large these rodents do not consume much perennial forage. Under local conditions it is possible that the reverse may be true.

According to the opinion of Vorhies and Taylor (1922, p. 34), the principal enemies of the banner-tail are the badger (*Taxidea taxus*) and the kit fox (*Vulpes macrotis*). Since these predators have been heavily trapped in the area considered by this paper, it is possible that the abundance in some localities of banner-tails, as well as Merriam's kangaroo rats, is due to the reduction of these natural predators. Here again, more study is needed.

In the case of wood rats, there seems to be little doubt that control is unnecessary. They rarely eat grass, their feeding being limited almost entirely to certain browse species usually regarded as undesirable by stockmen.

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SUBJECTS FOR FILING WILDLIFE LITERATURE

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In common with many others I have felt for several years the need of some system of quick reference to important wildlife literature. To meet this need I have built up for my own use a serviceable file, the outline of which I offer here as a contribution to a more practical and comprehensive filing arrangement.

My own system is intended primarily for younger workers and others who do not have access to extensive files, such as those of the Biological Survey. It is intended especially for those who have some access to the literature and who wish to build up their own reference lists. Offered suggestively rather than as a model, this outline contains the subjects under which I have about 12,000 references more or less satisfactorily arranged. It is longer than is desirable, perhaps, but represents an attempt to cover the general field, with some thought to future needs when a more diverse and extensive literature exists. There is of course no pretense of completeness.

On the whole, there is good reason, especially for inexperienced file-makers, to avoid a long list of filing subjects. Until the user becomes thoroughly familiar with such a system, even though it be his own, there is danger of getting lost in a large group of categories, both in filing and in trying to locate material. Professor Aldo Leopold finds ample for his purposes an arrangement having probably less than half of the divisions given here. The wildlife management classes at the University of Michigan make excellent use of a file containing less than 100 subjects. The important point is that both of these simplified files contain references to much of the valuable wildlife literature. It should clearly be recognized that some of the most serviceable personal reference files are made as the need arises, and therefore, "just grow." A deliberate attempt to devise a complete system in a short time may result in an impractical synthetic product.

To be serviceable, a *personal* file need not follow any formal system of classification or modern library procedure. For convenience, I consider it entirely proper to list *Swans* and *Mergansers* under *Migratory Game*, notwithstanding the fully protected status of the former, and the rather incorrect classification of the latter. In a related-subject arrangement, it is difficult to avoid such arbitrary placements. In my own file, convenience is given high priority, and has proved justifiable on the basis of time saved, and for other reasons. Dewey Decimal System numbers typed on cards facilitate reference location in libraries.

A related-subject arrangement has the excellent advantage of flexibility. The entire outline, or any division thereof, can be expanded to suit the interests of the user, or it may be shortened, rearranged, or otherwise manipulated to fit his needs. In the present outline, for example, the section on fur animals is somewhat detailed, while fishes are included under extremely broad headings. Under important wildlife groups

or subjects, i.e., *Farm Game* or *Cover*, *General* and *Foreign* headings are very useful.

The best method of filing, where the material is intended for personal reference, is probably a matter of choice. I prefer to file by grouped or related subjects, and as specifically as possible, a condition requiring a long list of file headings. Many workers prefer an alphabetical arrangement of their filing categories. This eliminates the advantage of grouping related material, but puts filing and relocation on a mechanical rather than a conditioned basis. An alphabetical arrangement has the advantage of simplicity and is therefore more easily used by a large student group. Perhaps the least desirable is to file by authors without consideration of subjects. In such files, any reference, the author of which is known, can be found with certainty and in a minimum of time, but such files become practically unusable if the names of authors are not available.

In any subject arrangement cross references are necessary. I have found satisfactory filing impossible without generous use of this device. To date, rather few papers have been as specific as Dalke's pheasant grit requirement[1] contribution, or Stoddard's discussion on the use of brush-cutters in wildlife management.[2] Yet, the first of these two papers required two cards for filing under *Pheasants* and *Grit*, the two most appropriate categories. In this case I considered *grit* to be the most specific subject, and accordingly filed the main reference card under this heading; the cross reference card was placed under *Pheasants*.

Lengthy papers usually have varied contents and are more likely to require additional cards than are short articles. Bennitt and Nagel's excellent survey of Missouri game and furbearers[3] could, and should, be filed under *Surveys*, but to index completely the material included in this work it is necessary to make one card for each of the 30-odd species or groups discussed, and one each for the general sections on fur animals, predators, and administration.

The labor of making duplicate cards can usually be reduced by filing a complete reference under the most appropriate subject, and as many "See ——" cards as necessary under the related subjects. I place nothing more than the author, title, and date on these supplementary cards. It is the file-maker's province to decide to what detail he shall go in filing, as warranted by his interests and the amount of literature and time available.

The mechanics of filing undoubtedly perplex every beginner. No system is so perfect as to accommodate every reference automatically. I am forced to use my own system thoughtfully, to study its divisions, and to solve certain difficulties arbitrarily. I habitually use the subject outline as a key in filing and looking up references. Every reference file, even the unorthodox and hybrid type so characteristic of personal prod-

[1] Dalke, Paul D. 1938. Amount of grit taken by pheasants in Southern Michigan. JOURN. WILDLIFE MANAGEMENT 2 (2): 53–54.

[2] Stoddard, Herbert L. 1937. Use of mechanical brush-cutters in wildlife management. *ibid.*, 1 (1–2): 42–44. illus.

[3] Bennitt, Rudolf and Werner O. Nagel. 1937. A survey of the resident game and furbearers of Missouri. Univ. Mo. Studies 12 (2): 1–215, illus.

ucts, must, if it works, be built on a definite filing policy. Otherwise, in large files, references become lost. As a general policy, I file as specifically as possible under a related subject arrangement, and use a simple cross index system to take care of references which could be placed under two or more headings.

Guide card mechanics may offer some difficulty. The subject list given here includes six major divisions with from one to five subordinate positions under each. Guide cards may be procured in 2-, 3-, 4-, and 5-tab positions. I needed six positions, yet as much space on the tabs as possible to accommodate the longer subjects. A satisfactory solution resulted from combining several sets each of two-position and three-position guides, thus giving five styles or one for each of the five subordinate positions. The width of these tabs was sufficient for the longer subject titles. Guides for the six major divisions I made easily from heavy blue bristol board, but a simpler solution could have been devised. All other guide cards are light brown, and all reference cards are white. I have not used colored cards to separate various subjects, but recognize their convenience and utility. Size is 3×5 inches in all cases. I printed the subjects on the tabs by hand, but typed tab covers would be more satisfactory—and in my case more attractive. In a fairly large file most of the guide cards are separated so widely by reference cards that overlapping, which results when two or more styles are mixed, does not hide the tab immediately following.

Reference cards, other than those used for cross references, should be complete and as conveniently arranged as possible. Typed rather than handwritten cards are desirable, and small size type is greatly to be preferred. A definite arrangement of author, title, date, publication, paging, illustrations, figures, maps, cost, and other points should be adopted. The following illustration is selected from my file:

Bennett, Logan J. 1938

The blue-winged teal, its ecology and management.

Collegiate Press, Inc., Iowa State College, Ames, Iowa. xiv+144 pp., 1 col. pl., 31 photos, 19 vig., 6 maps, 23 tables, lit. cited (71 titles). $1.50.

Abs. in Wildlife Review, 1938, 13: 9 (by W. L. McAtee).
Rev. in Ecology, 1938, 19 (3): 494–495 by Nicholas Collais.
Rev. in Bird-Lore, 1938, 40 (6): 443–444 by W. V.
Rev. in Auk, 1938, 55 (3): 565 by G. M. A.
Rev. in Wilson Bulletin, 1938, 50 (2): 149 by T. C. S.

This illustrates the method, as well as the several unorthodox features, I use in card making. The date in the upper right corner is a great convenience, since under each heading I file alphabetically by authors, and chronologically under authors represented by two

or more titles. I prefer a chronological over an alphabetical arrangement of titles in this instance because I have less difficulty in recalling the approximate date of publications than I do the first significant word of titles. The listing of reviews for important literature has proved worthwhile. This is easily done and requires little time unless one tries to cite every review for a large number of works.

Once abreast of the literature, card making can be reduced to a nearly routine basis. This is true also of reviews since reference cards for reviewed material are usually already made, and have only to be pulled out of the file for listing. Even if not made, it is a simple matter to type the complete reference card, the supplementary cards (if needed), and to list the review, all at the same time. I have found that two or three evenings per month are usually sufficient to cover the important literature received during that period.

The difficulty of collecting literature is probably the greatest obstacle confronting file-conscious field workers or others with headquarters at some distance from large libraries. An example is the wildlife technician on the average National Forest ranger district. Such locations are usually a day's drive, or more, from university or comparable libraries. Literature available in the district usually consists of a small number of the best known works, and three or four, rarely more, of the professional journals. Ordinarily, the technician has access to the *Journal of Forestry*, *Journal of Wildlife Management*, and *Wildlife Review*, and in a few cases the *Journal of Mammalogy*, *Ecology*, *American Wildlife*, *Wilson Bulletin*, *The Auk*, and others. This is a condition common to practically all field agencies; reference to forestry is merely illustrative. Professional journals are usually made available only through subscription by technicians or other personnel.

It is to these isolated but essential workers that *Wildlife Review* attains its greatest usefulness, and in a sense partly solves the literature problem. This valuable publication is held in high esteem by field personnel as well as others, and many depend almost entirely on it as a guide to recent literature. I know personally of at least one regional office which does so. For personal use, I do not consider it improper to make references directly from this publication, and in some instances I have included as well the abstracts given. It goes without saying that writers should consult the original literature before citing or quoting any reference. For several years I have been fortunate in having access to a great deal of the literature, but during that time I have found that it is possible to build decidedly serviceable reference files from the material given in *Wildlife Review* and the several well known professional periodicals.

Good abstracts greatly enhance the value and usefulness of reference cards, and like many others, I use the back of the card for this purpose. Abstracting, however, is likely to be too time consuming for most workers, although many summaries may be secured from *Wildlife Review*. Cards larger than 3×5 inches lend themselves better for abstracting use, but cost more, both for cards and containers, and require more room. I have never made a serious effort to abstract books, monographs, or

other lengthy papers in the small space allowed on a reference card, because to do so requires statements so general that usually they become worthless. Special items, however, may profitably be extracted.

Clear and direct titles are a great aid in filing. Perhaps I may be forgiven for a few statements concerning the importance of selecting good titles for wildlife articles and reports. There are cases when it is highly convenient to be able to file references from titles alone, however shocking this may be to a subject matter specialist. It is obviously impossible for workers to consult all of the literature, or even to obtain abstracts of it. Unless, therefore, one gathers a part of his references from bibliographies, literature cited, or elsewhere, he is certain to miss many valuable works. This is especially true of older papers that the filer would have no opportunity to get from *Wildlife Review* or other abstracting organs.

There have recently appeared two articles which admirably illustrate this point. "No Quarter" is by one of the foremost field investigators in wildlife work; and "Death Is upon Them," by a wildlife student, is an extremely well written article. Yet, from the titles alone, it is impossible to tell that the former describes the activities of a muskrat cut off from its retreat by solid ice, or that the latter, in the absence of its subtitle, is "the record of a weather-killed bob-white covey." My foregoing statements are not directed against good writing, of course, but are rather a contention that descriptive titles do not detract from the value or esthetic appeal of excellently composed wildlife literature.

A satisfactory system of filing bulletins and reprints is extremely useful. Most young workers do not have a sufficient number of papers to justify any special arrangement, but every such individual probably expects to accumulate literature, and many others well known in wildlife work already have personal libraries large enough to appreciate an orderly system of filing the material. It appears that numerous arrangements for filing reprints are in use, and that any method meeting the needs of the user is the one to be adopted. Anyone with a few hundred or more papers can well afford the time required for systematic organization.

Probably the simplest system, where only a limited number of papers is involved, is to group them into several categories—mammals, birds, fishes, forestry, etc.—and arrange alphabetically or chronologically under such headings. The filing of bulletins by states or geographical regions has obvious advantages and disadvantages. A very convenient and effective system is to number and file consecutively all papers as received; and when this accession figure is typed on the reference card or cards it becomes a simple matter to obtain the number of the paper desired and to locate it on the shelves. Numbers may be placed on the front cover in the upper right corner of bulletins and reprints.

Filing reprints and bulletins by subject is not precluded. If the reprint and card filing systems are the same, the subject under which the reference card is placed serves automatically to locate the paper in the reprint file. The order of filing under each subject should be alphabetical or chronological, as best fits the user's needs. If the reprint and

card systems are not the same, some suitable method of numbering or marking of reprints must be worked out; and to facilitate location, the number or designation used should be typed on the reference cards.

Owners of large reference and reprint files may type or stamp on every card and paper the Roman and Arabic numerals marking its position in the filing outline, i.e., IIIB5d(2), etc. This I have never done, chiefly because I frequently see the advantage of revising my subject list, which requires the changing of certain numbers and often considerable work. In cases where the filer's outline has met the tests of time, or the file is used by a large number of students or others, the specific designation of each card and paper as to its file position safeguards against losses and misplacements. Reprint boxes or mere wooden dividers serve to separate the various sections of the bulletin and reprint file.

Although scarcely a part of a filing system, I have found that keeping a miscellaneous list of natural history material, such as given under VI of this outline, is worthwhile. The advantages are too obvious for comment.

The wildlife profession, in its present status, is so immature that very few workers have found time to compile reference files, and consequently very few are in existence. Many game schools, and the regional and state offices of most agencies, are now without extensive guides to the literature. In view of this situation it would seem desirable for the Wildlife Society, through a Literature Committee, to draw up a standard list of filing subjects, under which workers or agencies would be able to file references to important papers in a more or less uniform manner.

The following outline gives with slight enlargement the subject arrangement under which I file:

SUBJECTS FOR FILING WILDLIFE LITERATURE

I. *General Literature*
- A. Texts
  - 1. Botanical
  - 2. Zoological
  - 3. Biological
- B. Historical
- C. Philosophical
- D. Bibliographies
  - 1. General Biological
  - 2. Mammals
  - 3. Birds
  - 4. Fishes
  - 5. Other Specialized Fields

II. *Organizational Literature*
- A. Proceedings
  - 1. Business—N. A. Wildlife Conference
  - 2. General Meetings—N. A. Wildlife Conference
  - 3. Other Wildlife Conference Meetings, without Papers
  - 4. Other Biological Meetings, without Papers
- B. Documents and Reports
  - 1. Legislative
  - 2. Judicial
  - 3. Executive
  - 4. Annual Reports
    - a. Federal
    - b. State
    - c. Other
- C. Organization of Agencies
  - 1. Biological Survey
  - 2. U. S. Department of Agriculture
  - 3. U. S. Department of the Interior
  - 4. Other Departments or Agencies

III. *Specific Literature*
- A. Game Species
  - 1. Farm Game
    - a. General

- b. Bobwhite
- c. Hungarian Partridge
- d. Pheasants
- e. Chukar Partridge
- f. Cottontail
- g. Fox Squirrel
- h. Foreign

2. Forest and Range Game
   - a. General
   - b. Ruffed Grouse
   - c. Prairie Chicken
   - d. Sharp-tailed Grouse
   - e. Sage Hen
   - f. Western Quails
   - g. Wild Turkeys
   - h. Ptarmigan
   - i. Hares
   - j. Jack Rabbits
   - k. Gray Squirrel
   - l. Whitetail Deer
   - m. Mule Deer
   - n. Antelope
   - o. Foreign
3. Wilderness Game
   - a. General
   - b. Elk
   - c. Caribou
   - d. Moose
   - e. Reindeer
   - f. Buffalo
   - g. Mountain Sheep
   - h. Mountain Goat
   - i. Musk Ox
   - j. Black Bears
   - k. Grizzly Bears
   - l. Alaska Brown Bears
   - m. Barren Ground Bears
   - n. Polar Bears
   - o. Foreign
4. Migratory Game
   - a. General
   - b. Doves
   - c. Game Shorebirds
   - d. Rails, Gallinules, and Coots
   - e. Waterfowl
     - (1) General
     - (2) Dabbling Ducks
     - (3) Diving Ducks
     - (4) Mergansers
     - (5) Geese
     - (6) Swans
   - f. Foreign
5. Game Fishes
   - a. Freshwater Fishes
     - (1) General
     - (2) Trout Family
     - (3) Pike Family
     - (4) Perch Family
     - (5) Foreign
   - b. Saltwater Fishes
     - (1) American Waters
     - (2) Foreign Waters

B. Non-game Species
1. Mammals
   - a. General
   - b. Fur Animals
     - (1) General
     - (2) Weasel Family
       - (a) Skunks
       - (b) Mink
       - (c) Weasel
       - (d) Otter
       - (e) Marten
       - (f) Fisher
       - (g) Badger
       - (h) Wolverine
       - (i) Sea Otter
     - (3) Cat Family
       - (a) House Cat
       - (b) Bobcat
       - (c) Lynx
     - (4) Dog Family
       - (a) Foxes
       - (b) Wolves and Coyotes
     - (5) Raccoon
     - (6) Ringtail Cat
     - (7) Beaver
     - (8) Muskrat
     - (9) Opossum
     - (10) Fur Seal
     - (11) Fur Rabbits
     - (12) Miscellaneous
     - (13) Foreign
   - c. Bats
   - d. Moles and Shrews
   - e. Cats, not Fur Species
   - f. Seals and Walruses, not Fur Species
   - g. Rodents
     - (1) General
     - (2) Ground Squirrels
     - (3) Woodchucks
     - (4) Prairie-dogs
     - (5) Flying Squirrels
     - (6) Pocket Gophers
     - (7) Pocket Rats and Mice

(8) Grasshopper Mice
(9) Harvest Mice
(10) White-footed Mice
(11) Rice Rats
(12) Cotton Rats
(13) Wood Rats
(14) Voles
(15) Round-tailed Muskrat
(16) Introduced Rats and Mice
(17) Mountain Beavers
(18) Jumping Mice
(19) Porcupines
(20) Foreign

h. Lagomorphs, not Game and Fur Species
(1) Pikas
(2) Pigmy Rabbits

i. Peccary
j. Armadillo
k. Manatee
l. Whales
m. Dolphins and Porpoises
n. Foreign

2. Birds
a. General
b. Loons
c. Grebes
d. Pelicans and allies
e. Herons, Ibises, and allies
f. Hawks and allies
(1) General
(2) Vultures
(3) Kites
(4) Hawks
(5) Eagles
(6) Ospreys
(7) Foreign
g. Owls
h. Cranes
i. Gulls, Auks, and allies
j. Pigeons
k. Cuckoos and allies
l. Goatsuckers and allies
m. Swifts and Hummingbirds
n. Kingfishers and allies
o. Woodpeckers
p. Perching Birds
(1) General
(2) Crows and Jays
(3) Blackbird Family
(4) Thrushes
(5) Starlings
(6) Shrikes
(7) Larks
(8) Sparrows
(9) Warblers
(10) Wrens
(11) Swallows
(12) Flycatchers
(13) Other Perching Birds
q. Foreign

3. Fishes
a. General
b. Commercial
c. Forage
d. Fancy
e. Foreign

4. Reptiles
a. General
b. Snakes
(1) Poisonous
(2) Non-poisonous
c. Lizards
d. Turtles
e. Alligators
f. Foreign

5. Amphibians
a. General
b. Frogs
c. Toads
d. Salamanders
e. Foreign

6. Invertebrates
a. General
b. Mollusks
c. Arthropods
(1) Crustaceans
(2) Insects
d. Other Invertebrates
e. Foreign

IV. *Management Literature*
A. Administration
1. General
2. Federal
3. State
4. Local and Private
5. Game Policy
6. Foreign

B. Management
1. General
2. By Game Classes
a. Farm Game
b. Forest and Range Game
c. Wilderness Game

- d. Migratory Game
3. Food
   - a. General
   - b. Natural
   - c. Food Patches
   - d. Winter Feeding
   - e. Grit
   - f. Foreign
4. Cover
   - a. General
   - b. Seasonal
   - c. Special Use
     - (1) Refuge
     - (2) Nesting
     - (3) Roosting
     - (4) Other Cover
   - d. Shelters
   - e. Burning
   - f. Clearing
   - g. Planting
     - (1) Reforestation
     - (2) Erosion Control
     - (3) Lake and Stream Improvement
     - (4) Wind Breaks, Fencerows, and Hedgerows
   - h. Foreign
5. Soil and Water
   - a. General
   - b. Erosion Control
   - c. Impounded Waters
   - d. Drainage and Reclamation
   - e. Lake and Stream Restoration
   - f. Pollution
   - g. Foreign
6. Propagation
   - a. General
   - b. Mammals
   - c. Birds
   - d. Fishes
   - e. Other Animals
   - f. Hatcheries and Game Farms
     - (1) Mammals
     - (2) Birds
     - (3) Fishes
   - (g) Rearing Pens and Grounds
     - (1) Mammals
     - (2) Birds
     - (3) Fishes
   - h. Restocking Techniques
     - (1) Mammals
     - (2) Birds
     - (3) Fishes
     - (4) Other Animals
   - i. Food and Water
   - j. Foreign
7. Refuges and Sanctuaries
   - a. General
   - b. Upland Game
   - c. Big Game
   - d. Migratory Game
   - e. Foreign
8. Measurement of Populations
   - a. Surveys
   - b. Census Methods and Techniques
     - (1) Mammals
     - (2) Birds
     - (3) Fishes
     - (4) Banding, Tagging, and Marking
   - c. Determination of Age and Condition
   - d. Determination of Productivity
9. Sanitation and Disease Prevention
   - a. General
   - b. Mammals
   - c. Birds
   - d. Fishes
   - e. Foreign
10. Predators and Predator Control
    - a. General
    - b. Livestock
    - c. Game
    - d. Fish
    - e. Other Animals
    - f. Bounty System
    - g. Government Hunters
    - h. Foreign
11. Vanishing Species
12. Wildlife and Fire
13. Range Wildlife Management
14. Wild Flower Management
15. Fur Farming
16. Miscellaneous Techniques
    - a. Maps and Mapping
    - b. Signs, Tracks, and Tracking
    - c. Specimen Making
17. Legal
    - a. Statutes and Laws
    - b. Game Law Enforcement
    - c. Warden System
    - d. Poaching and Bootlegging
18. Utilization

a. General
b. Recreational
(1) Hunting
(2) Fishing
(3) Aesthetic
c. Commercial
(1) Trapping
(2) Fishing
(3) Whaling
(4) Handling of Products
(5) Guiding and Camping
d. Crippling Losses
(1) General
(2) Mammals
(3) Birds
e. Wildlife Yields and Economics
f. Accidents
g. Fur Industry
h. Foreign

C. Education
1. Schools
2. Extension
3. Press
4. Radio
5. Movies
6. Sportsmen's Organizations
7. Farmer-Sportsman Organizations
8. Popular Literature
a. General
b. Mammals
c. Birds
d. Other Animals
e. Flora
f. Special Areas

D. Inter-Intra-Bureau Correlation
1. Wildlife and the Range
2. Wildlife and Forestry
3. Wildlife and Soil Conservation
4. Wildlife and Entomology
5. Wildlife and Mosquito Control
6. Wildlife and Engineering
7. Wildlife in National Parks

V. *Basic Research Literature*

A. Taxonomic
1. General Manuals
2. North American Fauna
3. Check and Local Lists
a. Mammals
b. Birds
c. Fishes
d. Reptiles
e. Amphibians
f. Other Animals

B. Life Histories
1. Mammals
2. Birds
3. Fishes
4. Reptiles
5. Amphibians

C. Food Habits
1. Mammals
2. Birds
3. Fishes
4. Reptiles
5. Amphibians

D. Breeding
1. Mammals
2. Birds
3. Fishes
4. Reptiles
5. Amphibians

E. Territorial Relationships
1. Distribution
2. Migration
3. Game Range
4. Specific Territory Requirements
a. Mammals
b. Birds
c. Fishes
d. Other Animals
5. Movement and Mobility
a. Mammals
b. Birds
c. Fishes
d. Other Animals

F. Cover Requirements
1. Mammals
2. Birds
3. Fishes
4. Other Animals

G. Populations
1. Densities
a. Mammals
b. Birds
c. Fishes
2. Relation of Density to Habitat
a. Mammals
b. Birds
c. Fishes
3. Cycles: Mammal-Bird-Fish
4. Inter-Intra-Specific Tolerances
a. Mammals
b. Birds

c. Fishes
5. Organization
a. Mammal Herds
b. Bird Flocks
c. Fish Schools
6. Sex Segregation
a. Mammals
b. Birds
c. Fishes

H. Diseases and Infestations
1. Bacterial
2. Parasitic
3. Poisoning
4. Mechanics of Epidemics

I. Principles of Predation
J. Physical Ecology
K. Physiological Studies
L. Nutritional Studies
M. Anatomical Studies
N. Embryological Studies
O. Histological Studies
P. Paleontological Studies
Q. Psychology and Behavior
R. Research Methods

VI. *Miscellaneous Lists Relating to Natural History*

A. National Scientific Organizations
B. National Scientific Journals
C. Wildlife Schools and Research Centers
D. State Organs and Publications
E. Big Game Refuges
F. Migratory Game Refuges
G. National Forests
H. National Parks
I. Important Museums
J. Outdoor Books
K. Outdoor Magazines
L. Important Fur Companies
M. Important Sporting Goods Companies
N. Addresses

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AN 8-YEAR CENSUS OF LESSER PRAIRIE CHICKENS[1]

Verne E. Davison

Inventory of wildlife is essential to to good management, and varying conditions in the field make it an annual requirement. Methods of enumeration, to be widely useful, must be dependable, inexpensive, and even more important, they must be applicable by such game managers as farmers, ranchers, and local wardens untrained in biology. Trained biologists have the responsibility of developing accurate and practicable ways of censusing game birds and mammals and of extending this knowledge wherever needed.

The habits of animals vary so greatly that effective observations concerning numbers must be planned with reference to the species concerned. The census method and the results described herein apply to the lesser prairie chicken (*Tympanuchus pallidicinctus*) on the Davison Ranch near Arnett, in western Oklahoma. The report covers 8 years including the most severe period of drouth on record. The method probably is applicable to the lesser prairie chicken throughout its range and possibly also to other species of prairie grouse.

The American Game Association established a game bird project on the ranch early in 1932 in co-operation with the Oklahoma State Game and Fish Commission, the Bureau of Biological Survey, and the author who carried out the plans as project manager. The original purpose included studies of factors governing the natural production of the lesser prairie chicken and bob-white (*Colinus virginianus*) and demonstrations of game management. W. L. McAtee briefed the results of the work to September 1935 in Biological Survey Leaflet BS-39 (March 1936). Most studies ceased at that time but the spring census of cock prairie chickens has been taken each year except 1937.

Within the Davison Ranch of approximately 100,000 acres, lie portions of the lesser prairie chicken's favored range, though less than half of the total ranch acreage is used by the species during the breeding season (March to September). An area 4 miles square (16 sections or 10,240 acres), typical of the best producing areas of comparable size or larger, was selected for intensive study. Surrounding lands with one minor exception belonged to the same ranch and all were managed together.

Method

Maps on 8-inches-to-the-mile scale were prepared and blueprinted to show fences, roads, windmills, fields, groves, and other permanent landmarks (Fig. 1). Census observations recorded on these maps proved invaluable both in analyzing progress and in presenting a clear picture of "gobbling ground" locations. Gobbling grounds are the small areas on which groups of cock birds "strut," "gobble," or "drum" every morning from late February to early June. It was on these spots that counts

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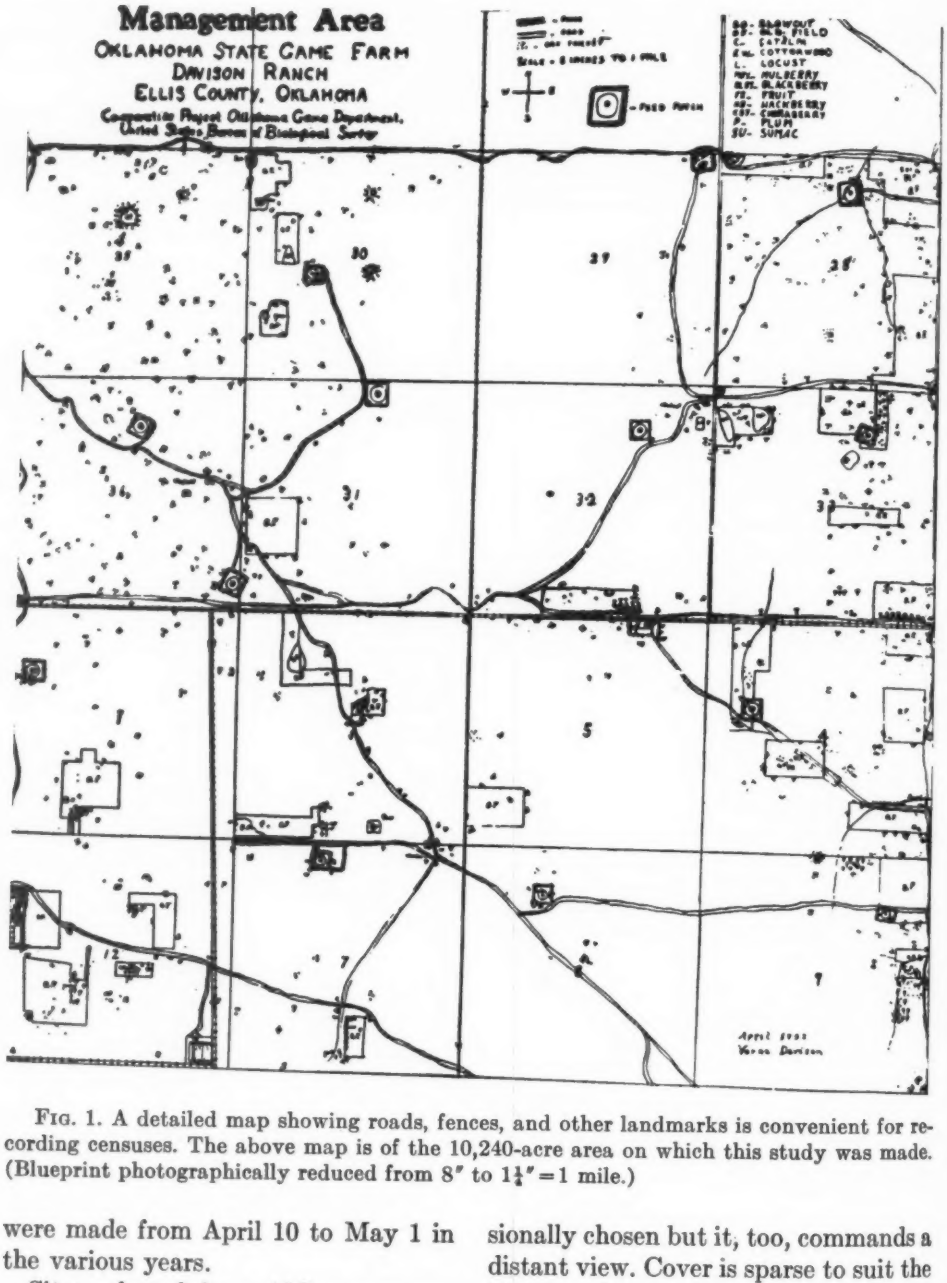

FIG. 1. A detailed map showing roads, fences, and other landmarks is convenient for recording censuses. The above map is of the 10,240-acre area on which this study was made. (Blueprint photographically reduced from 8″ to 1¼″ = 1 mile.)

were made from April 10 to May 1 in the various years.

Sites selected for gobbling are usually on high flat-topped ridges overlooking considerable areas. A slightly raised knoll in a broad valley is occasionally chosen but it, too, commands a distant view. Cover is sparse to suit the birds' evident desire to be in the open. This facilitates observation, and coupled with the calls of the birds, permits quick location of the grounds.

Observations could not be made from horseback or afoot because both methods disturbed the birds too greatly. A car was found to be satisfactory though the birds will always fly when a person steps out. Counts are made at dawn from the car, the driver never leaving the wheel. The birds usually flush when the car comes near but all will return in less than 10 minutes if the motor is turned off. An average of about 3 gobbling grounds can be censused each morning before gobbling ceases or becomes intermittent, usually some 2 hours after daylight. Results are found to be exactly the same day after day.

DISCUSSION

From the last week in February until about April 10, the cocks are contending for positions within the gobbling grounds. During this period they do not display their colors to the full, particularly the orange eyebrows that later appear almost as a hood across the head. Cocks cannot be distinguished readily from hens except by the most experienced observer unless eyebrows, raised neck tufts, puffed airsacs, and spread tail are evident. These are displays of courtship performed during the mating season when the hens come to the grounds; the first mating date is within two or three days of April 10. Since the number of hens on gobbling grounds is not constant, one must distinguish between the sexes and depend on the number of cock birds only for the counts.

Early morning counts were found to be exactly consistent except when high winds or rains lessened the birds' activities and the observer failed to see the motionless, well-concealed birds which nevertheless, were there. Evening counts are often low because some birds may feed until dusk.

In 1934 and 1935 previous banding activities proved their value to field observations particularly on the gobbling grounds. Bands placed on the left leg in 1933 and on the right in 1934 provided distinguishing marks which aided in determining that each male takes the same position relative to other birds on a given gobbling ground throughout the season.

Perhaps no accurate field counts can be made of the mature hens to determine the ratio between the sexes or the actual numbers of hens on an area. Nesting studies are very difficult because nests are hard to find and the abandonment of visited nests is high. It is also hard to obtain information during the first 5 or 6 weeks after the young birds are hatched, but on this particular range a second period of advantageous study occurs in July and August. Then the hen with her young can be caught in nets and the sex ratio, number per covey, and approximate age of the young may be determined. Such information when studied in connection with data on cock populations helps to bridge the gap left by the lack of information on numbers of hens and furnishes clues to reproduction on a given range that are of utmost importance to the game manager. The second favorable period of study may not be experienced in other areas where prairie grouse enumeration may be desirable. Spring censusing of cocks, however, is probably applicable wherever these birds occur.

RESULTS

The tables, graphs, and discussion

that follow give the results of censuses from 1932 to 1939 inclusive (except 1937) on the same 16-section study area of the Davison Ranch, Ellis County, Oklahoma.

Table 1 records the numbers of cock birds on each section by years together with the number of gobbling grounds on the total area. Some grounds were due to open season shooting. Throughout the period covered, no unusual losses were known to be attributable to winter storms despite rather low availability of normal winter food. Birds taken at intervals were all found to be in good condition.

The drouth no doubt affected the numbers of young per covey and the

TABLE 1

NUMBERS OF COCK PRAIRIE CHICKENS BY SECTIONS AND NUMBER OF GOBBLING GROUNDS BY YEARS

Section number	1932	1933	1934	1935	1936	1938	1939
1	36	67	41	31	26	39	38
4	5	6	6	0	0	0	7
5	38	35	38	20	21	32	40
6	0	11	17	12	10	0	6
7	34	35	5	12	17	2	0
8	33	52	25	41	23	8	8
9	29	31	26	30	25	19	39
12	55	84	44	51	38	28	28
25	42	22	4	20	16	8	1
28	0	12	14	8	9	7	4
29	56	84	38	49	38	34	66
30	52	47	27	23	14	17	28
31	32	56	36	32	26	33	31
32	17	6	0	1	0	1	12
33	26	31	20	23	18	28	15
36	35	27	12	7	8	10	29
Total for 16 sections	490	606	353	360	289	266	352
Number of grounds	34	40	28	31	29	18	24

on the line between sections and though recorded consistently in one section, the numbers would more nearly equalize if their relation could be shown to the acreage each ground actually serves. It is of interest that only about 3 hours each morning of 5 and 6 days were required to make the count for 1938 and 1939. Only 13 grounds have been occupied every year of the seven.

It should be remembered that the numbers apply to cock birds only in April of the year recorded. Changes are the result of degree of success in breeding and of losses both natural and those ratio of successful nests. The following records of netting operations in July, August, and September, show the average number of young per covey in each of four years (total young handled in parentheses): 1932, 7.5 (112); 1933, 6.47 (330); 1934, 5.46 (410); and 1935, 5.17 (181). No determination of nesting success was obtained. The ratio of cocks to hens among young birds in three years was: 1933, 140/100; 1934, 146/100; 1935, 163/100.

An open shooting season adjacent to the study area in the fall of 1933 was followed by a great decrease in numbers

within the area. No hunting was permitted on the study area, in fact, only the lands west of it were shot over, yet it is significant that losses on the four western sections were but slightly more than on the other sections in the area.

Some idea of the surplus that might properly have been taken in the fall of 1932 can be gained by comparing the figures for that year and for 1933, in light of the sex ratios for young birds. In order to retain a cock population equal to the 490 of 1932, only 116 cocks could be considered surplus (winter mortality if known should be deducted but the collection of some 15 or 16 cocks for food study may substitute for that factor). If hens remain in the ratio of 100 to 140 cocks, then 83 females would probably be shot to the 116 males. Thus no more than 199 birds could have been shot without reducing the breeding stock. This would be equivalent to 12.5 birds per section or 1 bird from each 43.2 acres and conservative management would have limited the harvest to 10 birds per section—160 total. On this occasion, because of lack of information the number could not have been set in advance but harvest records, spring censuses, and information on numbers of young per covey studied together should develop tables of reasonable expectancy for future guidance.

The minimum area that can be censused and yet be representative of a range is problematical. Study of Table 1 conclusively reveals that a single section may not show a dependable trend as the results for various sections are not consistent with the whole.

Passing to a larger unit of 4 sections within the study area, the northwest, northeast, southwest, southeast and center sectors, each 2 miles square, are compared with the total by graph in Figure 2. It was necessary to divide the total census by 4 to obtain a directly comparable figure for the smaller areas.

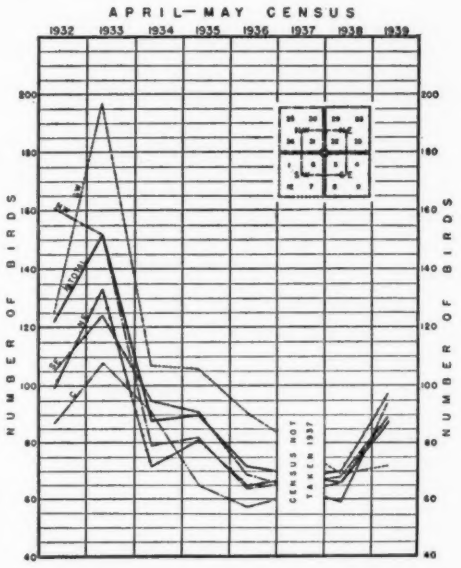

Fig. 2. The trends in numbers of cock prairie chickens on five sectors, each 2 miles square, are compared with the total number on a 4-mile square tract. Figures 3 and 4 show trends on areas of equal size but in strips 4 miles long and 1 mile wide.

Eight additional 4-section areas, each 4 miles long by 1 mile wide, are similarly graphed in figures 3 and 4.

While some variation is shown by the census data for the 13 areas of 4 sections each, and they are more uniform for the squares than for the long narrow blocks, they have similar trends. The figures show population increases from 1932 to 1933 in 12 of the 13 areas. The drop in each set of figures is remarkably uniform the following year. The graphs show varying trends from 1934 to 1935 but all were downward

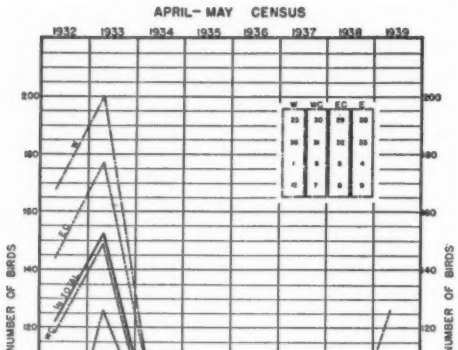

Fig. 3. A study of cock bird numbers on strips 4 miles long and 1 mile wide from west to east reveals trends similar to those for the whole study area. Figures 2 and 4 compare other 2,560-acre sectors to the whole 10,240-acre tract.

1935 to 1936 and are with two exceptions in the same relative positions as for 4 years earlier. All 13 reached their lowest point in 1936 or 1938 and one may surmise that a 1937 count might have produced the extreme low for each of them. A rise to 1939 is shown by all 13 though the rate is not uniform. Even if general trends are similarly indicated in the results for each 4-section sector, one must conclude that censusing a still larger area would more safely indicate the varying fortunes of the prairie chicken population.

Six areas 4 miles long by 2 miles wide are graphed in figure 5. In this test the graphs showing fluctuations in numbers for each sector remain closer to the average than those for areas one-half the size, and the general trends are more uniform. While these results show considerable improvement over those for 4- by 1-mile strips, they seem to have nearly the same factor of error that is evident in figures for the 2- by 2-mile squares, perhaps because the width is equal.

Data for four sectors of nine sections each in 3- by 3-mile squares are compared to those for 9/16 the total number in figure 6. Trends revealed by this graph are more consistent than in the others. It is evident that dependability increases with the size of area censused. Counts for 2- by 2- or 3- by 3-mile squares are accurate enough

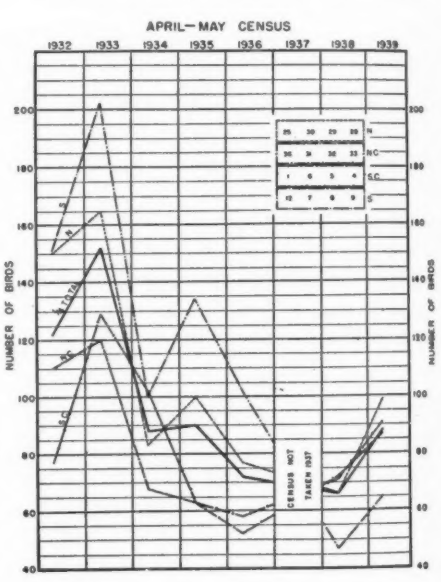

Fig. 4. The largest variation of trends is shown by two of these 4- by 1-mile sectors for 1934 and 1935 but by 1936 normal positions are again taken. Study of figures 2, 3, and 4 shows remarkable similarity to the whole of areas one-fourth the size, and indicates that a square area has a smaller factor of error than a long narrow strip of the same size.

to be significant and management based on the trends as shown by such counts should be safe.

Several considerations indicate the relative stability of the prairie chicken population. The similarity of increase and decrease in the several groupings figured to those of the total is astonishing when one considers that the daily flight range of lesser prairie chickens is commonly more than the radius of the entire study tract. It is doubly surprising because the northern half of the area was more heavily grazed than the southern half during the first 5 years of the study and the area contained part or all of 4 different fenced pastures in which the handling of stock varied considerably. Of equal significance is the fact that grain fields were within $1\frac{1}{2}$ miles of the west border while for the eastern part of the area only negligible amounts of grain were accessible.

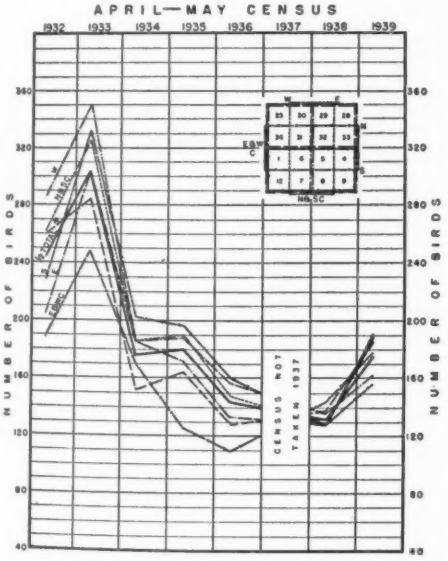

Fig. 5. Six sectors 4 miles long and 2 miles wide (8 sections) compare favorably in numbers of birds with one-half the total. No great difference in trend is shown by any of these divisions.

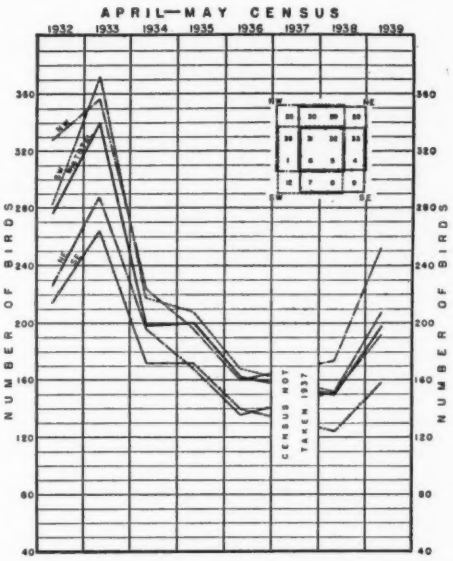

Fig. 6. The four sectors each 3 miles square, are fairly consistent with each other and with 9/16 of the total. Figures 2 and 6 indicate that square areas are preferable to long rectangular areas of about equal size for censusing and that counts on 2- by 2-, 3- by 3-, or 4- by 4-mile areas reveal dependable trends in prairie chicken numbers from one year to the next; the largest area is better than the smaller ones.

The figures given herein include no estimates but are exact counts, ground by ground, each year. Domestic stock can be counted no more accurately on the same range. The practical application of either wild or domestic animal management requires an annual inventory of the breeding stock. Inability of wildlife administrators to determine actual numbers on a range is responsible for too liberal hunting seasons and bag limits, for much misinformation distributed to sportsmen, and hence for overshooting.

Field research into the status of any bird is hampered if population figures are only estimated. The literature is colored by estimates that must exceed actual numbers if those made for Oklahoma prairie chickens, which by actual count prove to be much too high, form a reliable indicator. For example, the 1936–38 Biennial Report of the Oklahoma Game and Fish Department, which lists the numbers of prairie chicken in the five counties including the Davison ranch as of March 1938, gives a total of 14,790 birds of which 5,000 are recorded from the Davison ranch. Our studies indicate that at the peak of the population (1933) it is doubtful if the birds exceeded 3,000 on this ranch and continued records indicate less than half this number in March 1938. By a similar censusing of prairie chickens in Missouri, Bennitt[2] recorded the numbers 12,500 (1907), 8,467 (1931), 5,110 (1937), 6,600 (spring 1938) and 10,000 plus (estimated fall 1938). Lehmann[3] estimated the numbers of Attwater's prairie chicken (*Tympanuchus cupido attwateri*) in several Texas counties for 1937 by the "rope method." The total population of 8,711 is projected from an actual count of only 504 birds.

It should be emphasized that estimates and guess work make dependable management policies virtually impossible, and that prairie chickens of all species are so low in numbers that publicizing figures in excess of actuality is a menace to conservation of the birds.

[2] Bennitt, Rudolf. Some agricultural characteristics of the Missouri prairie chicken range. Trans. Fourth N. Amer. Wildlife Conference. 1939: 491–500.

[3] Lehmann, Valgene W. The heath hen of the South. Game, Fish, and Oyster Commission, Austin, Texas. July 1939.

SUMMARY

A spring census of lesser prairie chickens has been taken each year including 1932 to 1939 (except 1937), on the Davison Ranch in western Oklahoma. The counts were made of cocks only on gobbling grounds on which the same birds gather at dawn every day from late February to early June. A complete count of hens was found impossible.

The method is probably applicable throughout the range of the lesser prairie chicken and possibly to other prairie grouse. Its importance lies in its contribution to reliable annual inventory of the breeding stock as a basis of sound management.

The minimum area to be censused as representative of a range is indicated as 2×2 miles square (2,540 acres) but the results from areas 3×3 or 4×4 miles square are more dependable. The 4×4-mile tract (10,260 acres) can be censused in 5 or 6 days using about 3 hours each day.

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THE EFFECT OF CERTAIN LAND USE PRACTICES ON POPULATIONS OF BREEDING BIRDS IN SOUTHWESTERN OHIO

Charles A. Dambach and E. E. Good[1]

In the widespread adoption of soil and water conservation practices on farm land a very definite opportunity is offered to benefit wildlife. Apparent as the benefits may seem, biologists have presented little concrete data to demonstrate them. The conversion of large acreages from clean cultivation to permanent meadow, pasture, and woodland; the introduction of contour strip cropping; and the protection of woodlands from fire and grazing are generally considered to have distinct effects on farm wildlife populations. The extent and value of these effects, however, have not generally been made known.

With this need in view, study of farm breeding-bird populations was begun on the Soil Conservation Service Project at Hamilton, Ohio, in 1937, and continued through 1938 and 1939. Because it takes several years to establish revised land use programs and since data should be collected over a long period to be decisive, the facts presented here are not given as conclusive, rather as the basis of a progress report.

[1] The authors wish to acknowledge the aid of a number of persons in the Soil Conservation Service and the Ohio State University for helpful suggestions in conducting this study and preparing this report. We are indebted particularly to Dr. Charles F. Walker, of the Stone Laboratory, Ohio State University, under whom the study was initiated, for helpful suggestions in carrying out the study and preparing the manuscript. Particular thanks are due also to Dr. L. M. Dickerson, Regional Biologist, Soil Conservation Service, Dayton, Ohio, for criticism of the manuscript and Mr. R. J. Nesbit, Area Biologist of the Soil Conservation Service, Lima, Ohio, for aid in obtaining the 1939 census data.

Description of Area

The Hamilton Project Area lies in Butler County in southwestern Ohio. Its topography is typical of that section of the state—rolling, with level upland areas and broad, fertile, well-drained bottoms along the larger streams. The bottomlands are intensively cultivated except for narrow margins of the streams.

The breaks from first bottom to terrace are generally abrupt and are utilized for either pasture or woodlots. The original timber on these slopes was beech-maple, or often a mixture of tulip, walnut, beech, maple, ash, cherry, and oak. The rolling uplands were originally covered with beech-maple forests or with a phase of this type in which beech predominated. At present, much of the uplands are cleared except a few woodlots, most of which are pastured.

The fertility of the soil, as attested by crop yields, compares favorably with that of the state as a whole. The range of productivity is great. Much of the bottomland is unusually fertile, but a considerable amount of the upland is seriously eroded, and of limited value for crop production.

About 50 per cent of the land is in crops and most of the remainder is in

pasture. The farms average 112 acres, of which only 1.7 acres is protected woodland. Considerable livestock is kept, and much of the pasture has been overgrazed. Table 6 gives further details of land utilization before and after farmers signed co-operative agreements with the Soil Conservation Service.

METHOD

The information on bird populations was obtained by taking a census of singing males and by observing territorial behavior. Census data were recorded directly on a map by indicating the approximate territories occupied by breeding birds.

With the exception of small grain (wheat, oats, and rye) all fields studied were traversed in strips 50 to 150 feet wide, depending on the terrain, density of vegetation, and territorial aggressiveness of the birds. The census time varied but each field was covered with approximately the same intensity. Hours of active observation were from 4:30 A.M. to 9:00 or 9:30 A.M. As soon as birds stopped singing, work was discontinued for that day. In 1937 a half-inch rope 100 feet long was used to drag meadows after the morning singing period was over. This method was discontinued after a two-day trial because the results were not comparable to those obtained by recording singing males.

In conducting the census, two or more men worked close enough together to permit ordinary conversation. This made it possible to compare all observations and avoid duplication. One worker carried the map and recorded both his own observations and those reported to him. As each census strip was completed, the observers verified the records in order to be certain that territories were properly located and identifications correctly made. At each field, the party first decided upon the width of strip to be traversed, and the points where stops would be made —usually every 150 feet. Notes were then checked with the recorder.

In some instances grain fields were not strip-censused because of possible damage to the grain, but observations were made around their entire borders with the aid of 8-power binoculars. In approximately 50 per cent of the grain fields, however, strip-census was made by utilizing the unsown corn shock rows or occasional gaps left by skips in drilling.

In surveying woodlots, the observers worked some 75 feet apart and made stops at about 100-foot intervals. Halts were for periods of from 3 to 5 minutes, during which time all singing male territories were noted. Beofre proceeding, the observers tallied their findings with the recorder. Travel between stops was irregular to facilitate examination of likely nesting locations.

Records were kept of all proofs of nesting. Those considered most significant included: Finding nests, observing nest building activity, the carrying of food to young, and territorial expressions such as scolding by either sex or singing and fighting of males within recognizable territorial limits. Since a limited amount of time was available and numerous observations were needed, little time was spent attempting to locate nests when other evidence indicated nesting activity.

Although this method may not indicate actual numbers, it is believed ade-

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Contour strip-cropping on a southwestern Ohio farm. The uniformity of the large field in the foreground has been broken by alternating strips of different crops. Note the contrast to the large cornfield in the center background. In succeeding seasons the crops in this field will be completely changed. In the strip-cropped field, corn, small grain, and meadow will always be present. Territorial boundaries of such species as grasshopper sparrows are sharply marked by strips like these.

field will be completely changed. In the strip-cropped field, corn, small grain, and meadow will always be present. Territorial boundaries of such species as grasshopper sparrows are sharply marked by strips like these.

PLATE 2

quate for measuring relative populations. Obviously it does not accurately represent non-singing or nocturnal species, or those in which the females sometimes sing and it is invalidated to a degree by the counting of singing unmated males. To determine actual populations of these species would require a more intensive type of census than was practical in this study.

Observations were made in 1937 on June 17, 18, and 19; in 1938 from April 28 to May 3 and from June 9 to 11; and in 1939 from May 17 to 19. In 1937 and 1938 two observers participated and in 1939, three.

CENSUS DATA

Cropland—Differences in quality and density of cover as well as in plant composition sometimes occurred but an attempt was made to select fields characteristic of the project area and it is believed that the data obtained represent typical conditions for the years covered.

The data for all fields of a given crop are combined under appropriate headings. For instance, the grains, wheat, rye, and oats are grouped under small grain, and the heading, "meadows," includes both first- and second-year mixed meadows of red clover, timothy, alfalfa, and orchard grass.

Corn—Data from 3 years' observations on cornland in fields of 5 to 15 acres indicate that this crop supports the smallest breeding bird population of all those studied (Table 1). The average population per 100 acres of corn in non-stripped fields for 3 years was 3.23 pairs, with only one species of bird represented. Corn in strips, with 3.82 pairs per 100 acres, showed only a slightly higher population density and harbored but two species. The data are affected by variables, one of which is the time that fields were prepared for planting in relation to the date of the census. In 1937, corn had been in the ground nearly four weeks at the time the census was made, and opportunity had thus been afforded birds to establish nests. In contrast, the 1938 and 1939 censuses were conducted on many fields during or immediately after tillage. The population, however, probably will always be small, for cornfields provide a habitat utilized by only a few species, which in this locality have a low population density. Moreover, nesting opportunity in cornfields is limited mainly to the period between planting and the first cultivation. After that date nesting is hazardous because of the frequency of cultivations.

Small Grains—In small grains the average breeding bird population in large non-stripped fields was 10.26 pairs per 100 acres and in strip-cropped fields 27.35 pairs per 100 acres. Of the five species of birds present in the grain areas, 4 were found in stripped fields and 2 in fields that were not strip-cropped. All of those occurring in the strips and absent from the large fields (meadowlark, vesper sparrow, field sparrow) have at various times been recorded in such fields, but usually at or very near their margins (Table 2).

Meadow—During the years of this study there was considerable variation in the meadows censused. In 1937, following the serious drought of 1936, meadow growth was sparse. Meadows in 1938 and 1939 were much better in quality. On the whole, those in stripped fields were characterized by less dense growth and by a smaller percentage of

TABLE 1
BREEDING BIRD POPULATIONS IN CORN FIELDS

Crop	*Date of census*	*Number of fields*	*Number of strips*	*Number of acres*	*Bobwhite*	*Pheasant*	*Killdeer*	*Bobolink*	*Meadowlark*	*Redwing blackbird*	*Dickcissel*	*Grasshopper sparrow*	*Vesper sparrow*	*Field sparrow*	*Song sparrow*	*Number of species*	*Number of pairs*	*Number of pairs per 100 acres*	*Average number of pairs per 100 acres*
Corn	6/17/37 6/19/37	2		9.7			1									1	1	10.30	
Corn	4/28/38 5/ 3/38 6/9–11/38	6		51.9			2									1	2	3.85	
Corn	5/17/39 5/19/39	2		31.0												0	0	0	
TOTAL		10		92.6			3									1	3		3.23
Corn strips	6/17/37 6/19/37	3	16	34.3			1						2			2	3	8.74	
Corn strips	4/28/38 5/ 3/38 6/9–11/38	1	6	36.3												0	0	0	
Corn strips	5/17/39 5/19/39	1	2	7.8												0	0	0	
TOTAL		5	24	78.4			1						2			2	3		3.82

TABLE 2

BREEDING BIRD POPULATIONS IN SMALL GRAIN FIELDS

Crop	*Date of census*	*Number of fields*	*Number of strips*	*Number of acres*	*Bobwhite*	*Pheasant*	*Killdeer*	*Bobolink*	*Meadowlark*	*Redwing blackbird*	*Dickcissel*	*Grasshopper sparrow*	*Vesper sparrow*	*Field sparrow*	*Song sparrow*	*Number of species*	*Number of pairs*	*Number of pairs per 100 acres*	*Average number of pairs per 100 acres*
Small grain	6/17/37 6/19/37	4		22.5						2		1				2	3	13.3	
Small grain	4/28/38 5/ 3/38 6/9–11/38	1		4.5												0	0	0	
Small grain	5/17/39 5/19/39	4		51.0						3		2				2	5	9.8	
TOTAL		9		78.0						5		3				2	8		10.26
Small grain strip-cropped	6/17/37 6/19/37	3	10	34.9					1			12	6	2		4	21	60.17	
Small grain strip-cropped	4/28/38 5/ 3/38 6/9–11/38	2	8	53.9								6	4			2	10	18.60	
Small grain strip-cropped	5/17/39 5/19/39	1	6	42.8					1			3		1		3	5	11.68	
TOTAL		6	24	131.6					2			21	10	3		4	36		27.35

TABLE 3

BREEDING BIRD POPULATIONS IN MEADOW FIELDS

Crop	Date of census	Number of fields	Number of strips	Number of acres	Bobwhite	Pheasant	Killdeer	Bobolink	Meadowlark	Redwing blackbird	Dickcissel	Grasshopper sparrow	Vesper sparrow	Field sparrow	Song sparrow	Number of species	Number of pairs	Number of pairs per 100 acres	Average number of pairs per 100 acres
Meadow	6/17/37	5		60				1	4		2	9	3	4	2	7	25	41.66	
	6/19/37																		
Meadow	4/28/38	4		39.5					5			13	1		1	4	20	50.06	
	5/ 3/38																		
Meadow	5/17/39	4		32.0				4	2	3		9				4	18	56.25	
	5/19/39																		
TOTAL		13		131.5				5	11	3	2	31	4	4	3	8	63		47.90
Meadow strips	6/17/37	1	1	3								4	1	1		3	6	200.00	
	6/19/37																		
Meadow strips	5/17/39	2	12	47.7	1	1			5	1		24	6	3		7	41	85.95	
	5/19/39																		
TOTAL		3	13	50.7	1	1			5	1		28	7	4		7	47		92.73

legumes than other meadows studied. This was because they were either remnants of very old meadows or new plots seeded under adverse weather conditions. Often, in order to get strip cropping into effect at the earliest possible date, ploughing of old meadows was deferred for one or two years.

The average meadow population was 47.90 pairs per 100 acres on large non-stripped fields, and 92.73 pairs per 100 acres in contour strip-cropped fields. Meadows had a larger population in numbers of species and pairs of birds per unit of area than corn and small grain together (Table 3). In non-stripped meadows the number of pairs was about 15 times as great as in cornfields, and 4.5 times larger than in small grains. A similar relation existed between these crops in strips. The population for meadow strips was approximately 24 times as great as that in corn, and 3.5 times as great as that in small grain strips.

Contour Strip Cropping—The apparent role of contour strip cropping[2] in supporting larger populations of breeding song birds, as these data indicate, raises some interesting questions. Is it universally true? Is it a phenomenon of territory? Of position? Of some other unrecognized factor, or combination of factors? The first question can be answered, of course, only by further studies. The effect of crop margin on territory is probably an important factor, particularly in such crops as wheat, rye, and oats in which there are usually no openings. The present data show a marked difference in population between solid grain fields and grain in narrow strips (10.26 and 27.35 pairs per 100 acres, respectively).

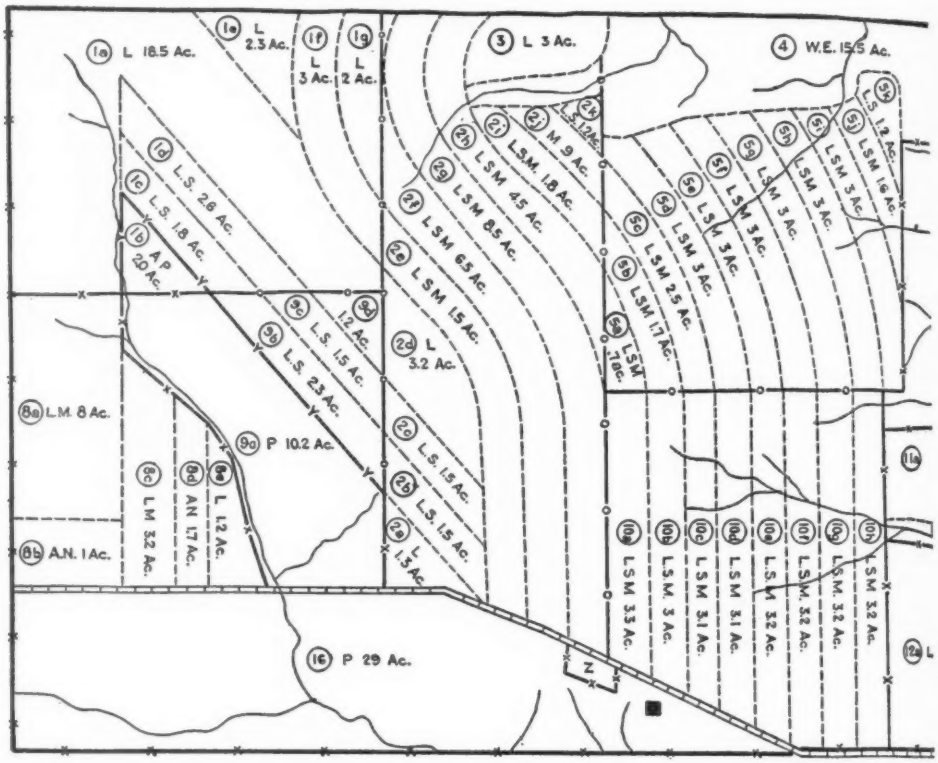
This difference is largely accounted for by the greater population of sparrows (grasshopper, vesper, field) in stripped fields—sparrows in stripped grain fields represented 94.16 per cent of the entire bird population, and in non-stripped grain fields 37.5 per cent. Observation of these species indicated their preference for territories with openings near the nesting sites. In strip cropping the proportion of openings is materially increased over that in solid field plantings. This factor is probably important also even for meadows, although in the area studied there was usually some variation in quality and composition of the stand in different parts of the fields.

Increase in crop margin varies with width of strip. Strips studied were from 98 to 128 feet in width. The actual increase on one farm censused was 34,070 feet, or 178.61 per cent of the original length (Figure 1). This margin is, however, a temporary one so far as position is concerned. In actual operation, permanent margin or border may be reduced to facilitate strip cropping as is illustrated in Figure 1.

The data available indicate that increased bird populations incident to strip cropping may result from increasing the number of suitable territories of the several species.[3] This is illustrated

[2] Alternating strips of a clean-tilled with a close-growing crop on the contour or across the general slope, as contrasted with solid field planting.

[3] Similar studies conducted for a two-year period in eastern Ohio on strips 28 to 42 feet in width do not indicate marked differences in population between large fields and stripped fields of the same crop. In this area farm bird populations are lower than in



CHANGE IN EDGE

1. Original permanent border	19,075 feet	
2. Permanent border after contour strip cropping established	15,750 feet	
3. Loss in permanent border	3,305 feet	
4. Increase of crop edge due to contour strip cropping	37,375 feet	
5. Total gain in crop edge (4 minus 3)	34,070 feet	
6. Percent gain in crop edge over original permanent border	178.61	

LEGEND

Permanent border, revised plan	———
New field borders, strip cropping	- - - -
Fence removed	—o—
New fence	—y—
Cropland	L
Strip cropping	S
Sod waterways	M
Pasture	P
Permanent meadow	AN
Woods	W

Scale—1 inch = 500 feet

Fig. 1. Effect of contour strip cropping on crop edge on King farm, Hamilton, Ohio Soil Conservation Service Project.

by the following experiences with grasshopper sparrows.

Territorial boundaries of this species are readily determined by their "land-marked" boundaries as well as actions of the birds. On one large field with strips 98 feet wide, territorial boundaries were marked in one direction by natural waterways and in the other by the borders of the strip. In a 14-acre pasture, which has a number of small knolls

southwestern Ohio and the narrow strips may be too small for acceptable bird nesting sites.

of dissimilar size and shape separated by deep cut waterways, five of these "islands" were occupied in 1937 by pairs of grasshopper sparrows, each defending its territory to the bounding waterways. On several occasions scuffles between grasshopper sparrows were observed when a male invaded the territory of another pair. When the conflict was over each combatant returned to a perch in his own territory and continued his characteristic song. In 1938, each knoll in the field was occupied, and in 1939, five pairs had established territories as in 1937.

Observations tend to show that contour strip cropping, due to its relative stability, offers an advantage to nesting birds that by habit return yearly to approximately the same territory (Figure 3). The usual 4-year crop rotation in southwestern Ohio is corn followed by wheat and two years of meadow. When a meadow is ploughed for corn, meadow-nesting birds are largely eliminated. Exclusion continues though to a lesser extent the following year when the field is in wheat. Under a system of strip cropping all three crops—corn, wheat, and meadow—often are present in a field at the same time.

Assuming a hundred acres of cropland in a 4-year rotation under the two different systems—solid and strip cropping—the total population and distribution would be as illustrated in Figure 2. This figure shows how a system of strip cropping may provide suitable habitat for crop nesting birds at about the same place year after year. By contrast, in large, solid fields with only one crop in a season, bird populations are subject to marked fluctuations as the rotation progresses. Starting with corn, the population becomes greater each year, reaching a peak during the years the field is in meadow. Thus bird populations in a solid field rotate with the crops, while in a strip-cropped field in which the complete rotation is always present relatively stable bird associations are accommodated. It would seem that the insect control value of birds also might be enhanced by strip cropping, since crops without large populations would be within the feeding range of individuals living among growths supporting greater bird populations.

In large meadows, sparrows (grasshopper, field, vesper, and song) made up 66.71 per cent of the species, and the red-winged blackbird, dickcissel, bobwhite, and meadowlark, 33.29 per cent. In stripped meadows sparrows represented 82.97 per cent, and meadowlark and red-winged blackbird, 14.75 per cent of the population, while bobolinks and dickcissels were entirely absent. Observations elsewhere in Ohio have indicated that quality of meadow is an important factor in determining populations of the redwing, bobolink, and dickcissel; i.e., these birds seem to nest most frequently in good quality meadow, particularly alfalfa.

The last two species exhibit marked fluctuations in populations locally from year to year, with no apparent change in quality or quantity of habitat. During the period of study dickcissels, for instance, were common in 1937 and very uncommon in 1938 and 1939. Bobolinks were common only in 1939.

Pasture—In the project area, pastures varied so greatly in terrain, quality, available water supply, and amount of thicket cover, that comparable samples were difficult to find. Several pastures

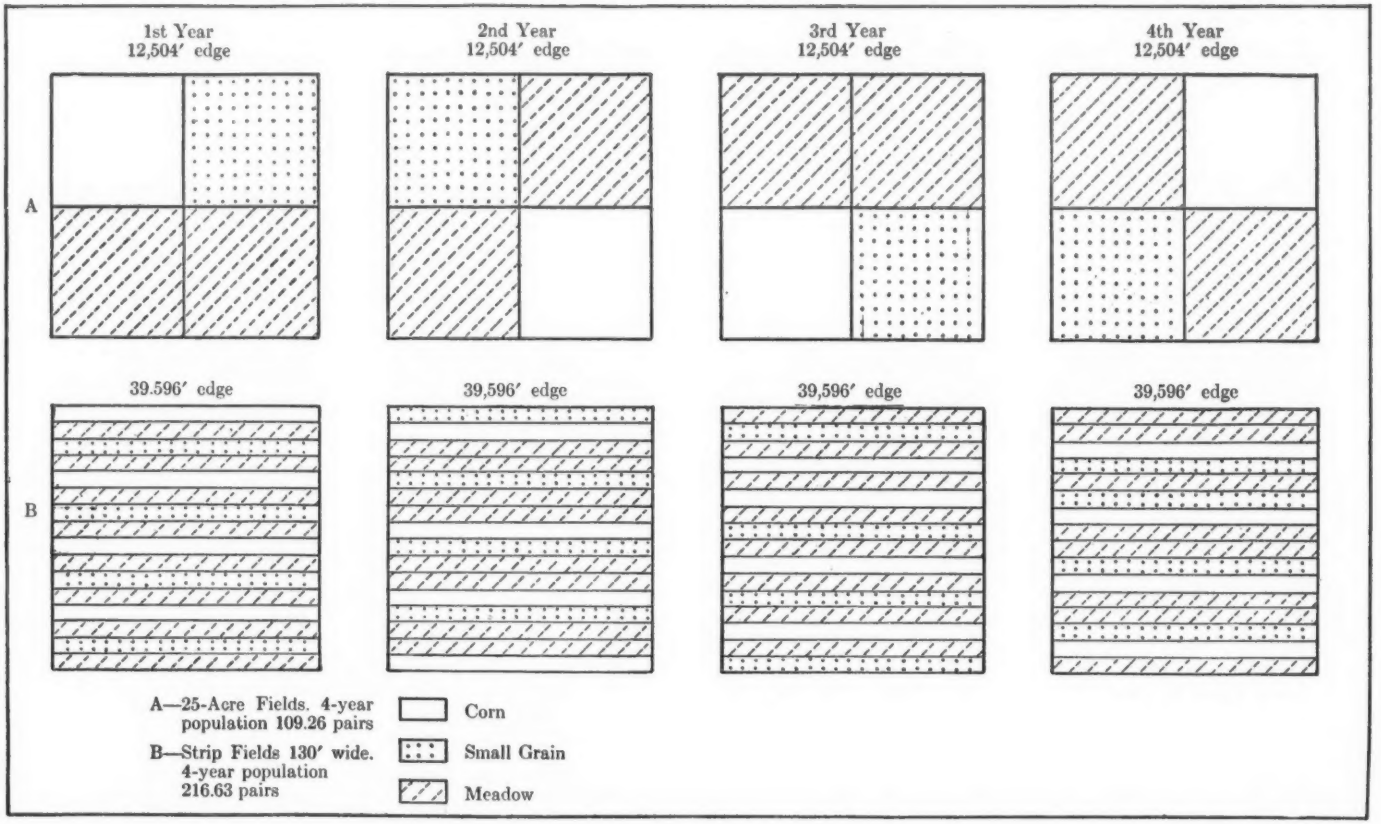


Fig. 2. Theoretical change in crop position and amount of crop edge on land farmed in large blocks, compared to a similar area farmed in strips and the breeding bird populations incident to the two systems. Based on data obtained on Hamilton, Ohio, project and the usual 4-year rotation common in Ohio.

TABLE 4

BREEDING BIRD POPULATIONS OF A TYPICAL UPLAND PASTURE IN SOUTHWESTERN OHIO

Year	Acres	Meadowlark	Grasshopper sparrow	Song sparrow	Species	Pairs	Pairs per 100 acres	
1937	14	2	5	1	3	8	57.14	
1938	14	2	7	1	3	10	71.42	
1939	14	2	5	1	3	8	57.14	
Total	42	6	17	3	9	26	61.90	Average

TABLE 5

BREEDING BIRD POPULATIONS IN PROTECTED AND GRAZED WOODS IN SOUTHWESTERN OHIO

	Protected woods Pairs 1939	*Grazed woods Pairs 1939*
Yellow-billed cuckoo Coccyzus a. americanus	1	
Ruby-throated hummingbird Archilochus colubris	1	
Northern flicker Colaptes auratus luteus	1	1
Red-bellied woodpecker Centurus carolinus	1	1
Hairy woodpecker Dryobates v. villosus	3	
Downy woodpecker Dryobates pubescens medianus	1	1
Crested flycatcher Myiarchus crinitus boreus	2	1
Acadian flycatcher Empidonax virescens	1	
Wood pewee Myiochanes virens	3	2
Eastern crow Corvus b. brachyrhynchos	3	
Carolina chickadee Penthestes c. carolinensis	3	
Tufted titmouse Baeolophus bicolor	5	1
White-breasted nuthatch Sitta c. carolinensis	1	
Carolina wren Thryothorus l. ludovicianus	5	
Wood thrush Hylocichla mustelina	2	
Blue-gray gnatcatcher Polioptila c. caerulea	6	2
European starling Sturnus v. vulgaris		2
Red-eyed vireo Vireo olivaceus	13	2
Cerulean warbler Dendroica cerulea	2	
Ovenbird Seiurus aurocapillus	1	
Kentucky warbler Oporornis formosus	7	
Scarlet tanager Piranga erythromelas		1
Eastern cardinal Richmondena c. cardinalis	1	
Indigo bunting Passerina cyanea	14	4
Towhee Pipilo e. erythrophthalmus	1	
Mississippi song sparrow Melospiza melodia beata	2	
Total pairs	80	18
Number of species	24	11
Number of woods	2	2
Number of acres	35.5	16.2
Total number of pairs per 100 acres	225.35	111.11
Number of species hole nesting	10	7
Number of pairs hole nesting	25	9
Percentage of total hole nesting	31.25	50.00

Fig. 2. Theoretical change in crop position and amount of crop edge on land farmed in large blocks, compared to a similar area farmed in strips and the breeding bird populations incident to the two systems. Based on data obtained on Hamilton, Ohio, project and the usual 4-year rotation common in Ohio.

in southwestern Ohio were studied, but data for them were so obviously affected by such factors as abundance of rose and hawthorn clumps that all but one were discarded as unrepresentative. In the pasture selected for study no brushy cover nor natural, open water

supply were present. The pasture had been treated with lime and phosphate in 1936. The bird population data are shown in Table 4.

Woodland—Woodland censuses were taken to determine the effects of grazing on bird populations. Four woods, two of which had been protected for at least 25 years, and two that had been grazed, were censused. Original composition of the woods was presumably quite similar as the sites were comparable. The protected woods was mainly beech-maple with a mixture of tulip, ash, cherry, walnut, and oak on the slopes. An excellent understory of young trees of these species, as well as of dogwood, black haw, maple-leaf viburnum, and spice bush was present. One of the grazed woods was largely maple, oak, and ash, with numerous beech snags. The other woods contained a preponderance of oak, ash, and red maple, with some sweet gum; parts of it might be considered transitional between swamp forest and beech-maple. Both woods were closely grazed, but not to the point where all ground cover was obliterated. An attempt was made to avoid the worst examples of over-grazing.

The data (Table 5) show that protected woods support more than twice the population either in individuals or species per unit of area than do grazed woods.

It is interesting to note that 50 per cent of the species in the grazed woods were hole-nesters as compared to 31.25 per cent in the protected woods. None of the species in the grazed woods nested on the ground, and only one, the indigo bunting, in herbaceous or shrubby cover.

TABLE 6

EFFECT OF LAND USE CHANGES ON BREEDING BIRD POPULATIONS ON FARMS PLANNED BY THE SOIL CONSERVATION SERVICE IN THE INDIAN CREEK PROJECT AREA, BUTLER COUNTY, OHIO

Land use	Acres before agreement	Acres after agreement	Increase or decrease in acres	Average number of pairs per 100 acres	Change in population		
					Original number of pairs	Increase or decrease in pairs	Percentage difference in pairs
Pasture	2,546	2,647	+101	61.90	1,575	+ 63	+ 4.00
Meadow (not strip-cropped)	1,670	1,948	+278	47.90	800	+ 133	+ 16.62
Meadow in Strips	0	482	+482	92.73	0	+ 447	
Corn (not strip-cropped)	2,090	1,246	−844	3.23	68	− 27	− 39.70
Corn in Strips	0	241	+241	3.82	0	+ 9	
Small Grain (not strip-cropped)	1,678	1,312	−365	10.26	172	− 37	− 21.51
Small Grain in Strips	0	241	+241	27.35	0	+ 65	
Grazed Woods	367	0	−367	111.11	408	− 408	−100.00
Protected Woods	118	566	+488	225.35	266	+1,010	+379.69
Total					3,289	+1,255	+ 38.16

Total anticipated pairs after land use practices are fully effective, 4,644

Farm Populations—On the basis of the data obtained in this study, an attempt was made to compute the total changes in bird population which might be expected to result from altered land use on farms in the Hamilton Area that are under agreement with the Soil Conservation Service (Table 6). Other practices not yet developed far enough to show their effect upon bird populations may materially add to the figures presented.

In order of their importance land use practices in this area that contribute most to increasing the number of breeding birds are: establishing new woodlots by planting, protecting woodland from grazing,[4] contour strip cropping, and increasing meadow. The total bird population on the farms after present land use practices have become fully effective would be 38.16 per cent greater. Striking as this figure is, it does not indicate all of the possibilities as on most of the re-planned farms other practices are being carried out that are distinctly beneficial to breeding birds, but for which no specific data are available. These include: (1) Improvement in quality of meadows and pasture following conservation cropping practices such as strip cropping, permanent sod waterways, contour tillage, and soil improvement by lime and fertilizer; (2) introduction of food and cover plants in woodland borders, new forest plantings, and protected wildlife areas; and (3) protection of woodland, odd corners, and so-called idle land from fire, grazing, and cutting.

[4] The change in population following protection of woodland from grazing and establishing new woods will, of course, be gradual. In the absence of data showing the progressive nature of this change the populations for mature protected woods are given. In grazed woods this change is probably quite rapid. Of the increase in protected woods 81.8 per cent is accounted for by protection of existing woods from grazing. The data on woodland populations, while representing but one year's data, compare favorably with those obtained by others.

SUMMARY

Counts of breeding bird populations were made on representative farms in the Soil Conservation Service demonstration project area in Butler County, southwestern Ohio. The data obtained represent only 3 years' observations on a necessarily small sample, but the following generalizations are believed warranted.

Censuses on croplands indicated that meadow leads in number of pairs of breeding birds per acre, and in number of species. Small grains and corn follow in that order.

Strip-cropped fields had a larger population of breeding birds than fields of the same crops not in strips. The effect of strip cropping may be due to a number of factors, of which the establishment of acceptable territories with smaller boundaries than would be likely in large fields, and continuity of habitat are believed to be of first importance. Certain species, such as red-winged blackbirds, bobolinks and dickcissels were not found as abundantly in strips as in large meadows.

Protected woodlands support greater populations, both in number of pairs and in species, than grazed woods of similar composition.

Considering only conservation practices that affect the greatest percentage of the land, larger populations (nearly 40 per cent in this instance) of breeding

birds may be expected on farms replanned for soil conservation than on those where no changes are made.

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A SIMPLE DEER REPELLENT FOR CONIFER PLANTATIONS

Siegfried Weiss

While a student at the Royal Bavarian Forest Academy, I witnessed the use of certain deer repellents on young conifer plantations, in areas where browsing by the European red deer was excessive. The effectiveness of these repellents led me to try one of a simple type under American conditions. Several of the European formulas were quite complicated, but that finally selected is easily prepared and can be applied at a minimum cost. The ingredients are hydrated (or slaked) lime, cowdung, and water.

During the winter of 1937–38 a test was made on the Childs-Walcott forest at Norfolk, Connecticut, where white-tailed deer, after being protected over a long period, had become destructive. Their persistent browing on young conifers had made it advisable either to control the browsing or to discontinue planting. As most of the browsing occurred during the winter, treatment was begun in the fall of 1937 on plantations in the height classes (up to 6′) in which the terminal buds were within reach of the deer.

The repellent was applied to all terminal buds. No careful record was kept the first winter, but a marked decrease in browsing was noted. The application was very persistent and showed no signs of having been washed off by the winter rains and snows. It was decided that the repellent warranted further investigation as to its effectiveness and its influence, if any, on bud development.

The proportions in the repellent were approximately one part hydrated lime to five parts fresh cowdung and enough water to produce a mix of about the consistency of rather thin plaster. Upon addition of the hydrated lime, the cowdung lost most of its characteristic odor. The mixture was carried in a pail and applied to the terminal buds by means of a medium (3″) paint brush. A twelve-quart pail held enough to treat about one thousand 3-foot trees, or roughly an acre planted 6′×6′.

In November, 1938, three sample plots were established. Each consisted of one hundred Norway spruces in a 5-year-old plantation of 2-1 stock, ranging from 1 to 3 feet in height. Careful consideration was given when laying out the plots, to the location of deer runs and proximity of cover. Tracks in freshly fallen snow showed that deer often frequented all the plots and adjacent areas in considerable numbers and that they wandered about without showing noticeable preference for any one of them. Browsing was very heavy in the untreated area, apparently at least 75% of the terminals being cropped.

The site of these plots was on a slope facing north, adjacent to wooded areas. The forest type bordering on the east was predominantly uneven-aged mixed hardwood with some hemlock; on the north there was a white pine plantation, and on the west one of red pines, both in the pole stage. The spruces had been set out in a clear-cut hardwood area of about three acres. The resulting

TABLE 1

NUMBER OF TERMINALS BROWSED BY DEER IN TEST PLOTS BY MONTHS[1]

Month ending	Plot A All treated	Plot B		Plot C All untreated
		Treated half	Untreated half	
December 15	0	0	3	4
January 15	16	6	27	63
February 15	3	1	3	13
March 15	0	0	1	1
April 15	0	0	0	0
May 31	0	0	0	0
Totals	19	7	34	81

[1] A slight excess is noticeable in this table over the figures in Table 2 due to ice and snow covering the markers in some cases, and the strings being lost in others. Corrected final figures are given in Table 2.

sprout growth was 5 years old at the time of this study and subject to heavy browsing.

Application of the repellent was made on November 15, 1938. In plot A the terminal buds were 100% treated. In the adjacent plot B alternate trees were daubed to learn whether the odor might protect nearby untreated trees. Observation later, however, showed that the repellent effect was probably entirely dependent on the sense of taste. Plot C was left untreated as a control.

Monthly examinations of the plots were made from December through May to tally the browsing and deter-

TABLE 2

RESULTS OF FINAL PLOT EXAMINATION

Plot	Number of trees	%	Bud development					
			Out	%	Slipping	%	Not slipping	%
A[1]								
Terminal browsed	17	17	64	64	32	32	4	4
Terminal not browsed	83	83						
B[2]								
Treated								
Terminal browsed	8	16	30	60	17	34	3	6
Terminal not browsed	42	84						
Untreated								
Terminal browsed	30	60	21	42	18	36	11	22
Terminal not browsed	20	40						
C								
Terminal browsed	70	70	55	55	29	29	16	16
Terminal not browsed	30	30						

Final percentages of browsed trees (combined plots)
Untreated 66% browsed
Treated 17% browsed

[1] Plot A—2 treated buds dead but surrounding treated buds alive.
[2] Plot B—1 treated bud dead.

mine if the repellent injured the buds or retarded their development. Emphasis was placed on this latter objective only after the buds began opening in the spring. During the examinations, trees having their terminal bud browsed since the previous inspection were marked with colored strings. Lateral bud browsing was recorded at first, but later abandoned as these buds were not treated and browsing upon them was fairly uniform for all of the trees.

OBSERVATIONS

The intensity of browsing by months is shown in Table 1. These figures show that browsing was heaviest when snow depth was greatest (at times during January and February the snow depth reached 16″–18″). A midwinter thaw caused a small brook to flood part of plot C and cover about a dozen of the smaller trees with ice. This might have influenced the amount of browsing in that plot.

On May 31, 1939, the final check on the plots was made to determine exactly the total amount of browsing on 1939 terminal buds, and the effect of the repellent on bud development, which at that time was in various phases of slipping, i.e., opening of the bud scales. The figures in Table 2 were derived from this inspection.

The data on bud development show that the buds on treated, were opening as readily as those on untreated, trees. Dead terminal buds were found on three treated trees. Careful examination of untreated trees outside the test plots, especially in a small moraine sink also revealed dead terminal buds, probably killed by late frosts.

CONCLUSIONS

1. The 1–5 hydrated lime-cowdung mixture makes a rather effective deer repellent.
2. Bud development was not retarded nor the buds injured by the repellent.
3. Due to cheapness, ease of application, effectiveness, and lack of damage, the hydrated lime-cowdung mixture can be safely called a good deer repellent for the northern states.

ACKNOWLEDGEMENTS

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THE SUMMER FOOD OF MINKS AND RACCOONS ON THE MONTEZUMA MARSH, NEW YORK

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The great Montezuma Marsh of Central New York has long been a favorite among field naturalists. Its varied plant and animal life has provided source material for many studies. Years ago much of this area was drained and converted into truck farms; the water in many instances has been drawn off periodically to supply the barge canal. Yet thousands of acres still persist, a safe haven for wildlife in an area otherwise largely devoted to agriculture. Much of the marsh has recently been purchased by the United States Biological Survey which has made it a preserve for wildfowl. Three thousand acres between Savannah and Clyde, New York, are owned by Sylvester C. Vanderbilt, who has graciously allowed me free access to his holdings and encouraged in every way my studies of this remarkable area. While the water level in the New York State Barge Canal influences the tract owned by Mr. Vanderbilt, he has, by judicious placement of canals and sluices, been able in part to regulate the water level on his property, which is primarily a muskrat marsh.

Of the plants, cat-tails (*Typha angustifolia* and *T. latifolia*) dominate the marsh. Other abundant and important growths are swamp loosestrife (*Decodon verticillatus*), arrow arum (*Peltandra virginica*), rush (*Juncus effusus*), reed canary grass (*Phalaris arundinacea*), rice cut-grass (*Leersia oryzoides*), and bur-reed (*Sparganium eurycarpum*). Plants of the area have been listed by Saunders (1926). About the borders many shrubs grow in rank profusion. Among the more important of these are the silky cornel (*Cornus amomum*), red-osier (*C. stolonifera*), wild cherries (*Prunus virginiana* and *P. serotina*) wild grape (*Vitis vulpina*), wild apples, and numerous others. Mr. Vanderbilt has planted patches of corn near the marsh to provide food for the large populations of pheasants and ducks that winter on the area. Many fruit-bearing shrubs grow on the border, or on higher sandy ridges not far distant.

The area is a mecca for all wildlife. Grebes, rails, gallinules, coots, herons, bitterns, and several species of ducks (green-winged and blue-winged teals, black ducks, shovellers, and wood ducks) nest within its borders. Above all it provides abundant food and suitable cover for thousands of muskrats. The owner annually harvests several thousand pelts and this trapping tends to prevent undue destruction of the cat-tail roots by an excessive population of these rodents.

On July 14 and September 21, 1939 I visited this marsh for the purpose of making a general survey of the animal life and expressly to collect turtles. On each occasion the scats of minks and raccoons were abundant and I collected several hundreds. These were subsequently examined and the determinations made of their contents as listed below. I believe the results are similar to what one might expect to find in any like habitat in the northeastern United States.

Many miles of ditches have been dug throughout the swamp to maintain the water at certain levels. These ditches are from 5 to 7 feet wide and about one foot deep. The soil is piled to one side and as it settles, forms a convenient highway for minks and raccoons, where large numbers of scats of both species are deposited. Mink droppings are found in some numbers also on planks, stumps, and other prominences about the small pools throughout the swamp, as well as on the green mats of *Eleocharis acicularis* that border the wetter places. The New York Central railroad tracks run through the center of the marsh, and the culverts and spans beneath the bridges are regular travelways for minks. About the time the leaves commence to fall, minks are said to hide their droppings, repairing regularly to cavities formed by overturned roots, partially excavated muskrat houses, and similar places. From my limited observations, this assertion seems correct, for the droppings of these animals are no longer found after early October in such exposed places as during the summer. Raccoon droppings occurred in similar places, but considerable numbers were found also about the roots of willows, particularly those that had been uprooted by storms. I was told by Mr. Vanderbilt that certain "stations" are used regularly and one can invariably expect to find scats there.

FOOD OF MINKS

While collecting the droppings of these animals, I made observations as opportunity permitted, on the available foods and their relative abundance. Seining in the small pools of the marsh and in the slowly flowing streams that drain into the Clyde River and the New York State Barge Canal revealed many fishes of relatively few species. By far the most abundant were the golden shiner (*Notemigonus crysoleucas*); common sunfish (*Eupomotis gibbosus*); and carp (*Cyprinus carpio*); there were also a few bowfins (*Amia calva*). Many large aquatic insects were present but crayfishes were totally lacking. I collected none and was told that these crustaceans were seldom seen in the marsh.

Great numbers of small frogs (*Rana pipiens* and *R. palustris*) were present in all parts of the lowland; indeed, I have never seen them so numerous. In the beds of *Ludwigia palustris*, which covered the bottom of the older drainage ditches, I counted 30 frogs in an area scarcely exceeding 250 square feet.

Western painted turtles were very abundant and on September 21 numerous newly hatched snapping turtles were moving in the dry drainage ditches. Garter snakes and water snake were abundant.

Red-winged blackbirds were numerous and various species of swallows had commenced to flock to the cat-tails for the night by mid-September. Meadow mice were not common, mole sign (Condylura) was apparent, but the dominant species of the marsh was the muskrat. The fresh droppings of these animals and their diggings and trails were everywhere and were particularly obvious due to the low water. From my observations I concluded that, at the time of collecting the scats, muskrats, frogs, golden shiners, aquatic insects, and small turtles, in the order named,

were the most likely foods to attract the mink.

One hundred and seventy-nine mink droppings were collected on July 14 and 147 on September 21, totaling 326. Of these 300 were examined; the determinations of their contents are listed in Table 1.

TABLE 1

PER CENT OF OCCURRENCE AND BULK PERCENTAGE OF FOOD ITEMS IN 300 MINK SCATS FROM THE MONTEZUMA MARSH, NEW YORK, SUMMER OF 1939

Food	*Per cent of occurrence*	*Percentage by bulk*
Muskrat	49.33	37.95
Fish	41.00	27.25
Aquatic beetles	39.33	13.85
Birds	9.66	9.05
Frogs	5.66	3.35
Mice	3.00	3.00
Snake	1.00	2.70
Rabbit	1.00	1.00
Turtles	.66	1.12
Mole (Condylura)	.66	.40
Undetermined mammal	.33	.33
Sand	1.33	trace
Snails	.33	trace

DISCUSSION OF MINK FOOD

From close analysis of the droppings, it is possible to determine not only the identity of the species eaten but also something as to their sizes. In the many scats that contained muskrat remains, a number held, in addition to the twisted mass of fur, many small bones and claws. The small size of the claws suggests that the muskrats captured by the minks were largely kits.

From the perfect fish vertebrae and the abundance of small cycloid scales, it was possible to determine that the great majority of the fishes were golden shiners, probably averaging from 3 to 4 inches in length. No other fish species was recognized.

It was rather surprising to note the large number of insects that the minks had eaten. The greater part were large diving beetles, Dytiscus, readily recognized by the peculiar discs on their tarsal segments.

Of the 29 scats that contained bird remains, in only three could I determine the species. One included robin remains, and the other two fragments of the feet of swallows. According to the size of bone particles and feather stubs, all the other remains also were of small birds.

In view of the great number present, it is rather surprising that so few frogs were eaten. It is not likely that more than the 17 scats in which frog bones were recognized contained such fragments. Remains of Microtus and Peromyscus were recognized in 9 droppings, the former being most frequent. Small turtles (probably Chrysemys) and snakes (Thamnophis?) were represented in 5 scats. The scats contained hardly enough sand to record, yet we know that sometimes in winter the rectum of minks and weasels may be fully distended with mineral matter. The fragmentary snail remains were too small for identification.

FOOD OF RACCOONS

According to Dearborn (1932), the volumetric indices of about 500 raccoon feces, collected in southern Michigan (presumably mostly in summer), indicated that crayfishes (58.99), oats and corn (20.20), fruit (12.22) and insects (5.34) were the important foods. I have reported elsewhere on the fall and winter food of the raccoon in New York State (Hamilton, 1936). The principal foods at that season appeared to be

mast and grains (44 per cent), fruits (25 per cent), earthworms, small mammals, and insects. The summer food of the raccoon has not received much study by naturalists in the northeastern states.

The results of analyses of 163 scats are reported in Table 2. Of these, 68 were collected on July 14, and 95 in September, 1939. The high preponderance of fruits may be attributed to their abundance at this later season. The fruits of choke cherry and rum cherry were available from July until late fall, and the pale blue berries of *Cornus amomum* ripened in late August or early September. Grapes were fairly abundant, ripening in mid-August and persisting long after severe frosts had occurred. Corn available through late July and August, was relatively scarce in the area. Insects were abundant all through the warmer months but the forms most often eaten (grasshoppers and crickets) reached their peak in late summer and early fall. In view of the great abundance of frogs, the small number eaten is surprising. The same impression prevails with respect to the muskrat, but it may be that raccoons are not usually given to eating these animals.

From Table 2 it may be seen that fruits are the most important item in the summer dietary of the raccoon. Wild fruits occurred in 84.66 per cent of the 163 scats examined and comprised 72.12 per cent of their bulk. This study indicates once more that animals, within limits, feed upon whatever is most easily obtained.

Nineteen scats of the raccoon taken along the banks of the Schoharie River near Middleburg, New York during August, 1938, contained chiefly the remains of crayfishes, with some insects, and a small quantity of corn.

TABLE 2

PER CENT OF OCCURRENCE AND BULK PERCENTAGE OF FOOD ITEMS IN 163 RACCOON SCATS FROM THE MONTEZUMA MARSH, NEW YORK, SUMMER OF 1939

Food	*Per cent of occurrence*	*Percentage by bulk*
Wild cherries (Prunus virginiana and P. serotina)	57.67	38.15
Silky cornel (Cornus amomum)	36.20	26.56
Corn	4.30	6.65
Insects	41.72	4.26
Muskrat	7.99	4.07
Grapes	4.91	3.70
Mice	4.91	3.06
Turtle	3.07	2.23
Frogs	3.70	2.10
Apple	8.59	1.97
Snails	4.30	1.78
Snakes	3.70	1.67
Grass	6.13	1.29
Gray Squirrel	1.23	.74
Blackberry	4.30	.56
Undetermined fruit	2.45	1.18
Shrew (Blarina)	.61	trace

SUMMARY

A collection of 300 mink scats and 163 raccoon scats was made on the Montezuma Marsh of central New York during the summer of 1939. At the same time a brief survey of available foods was made on the marsh and these have been listed.

Examination of the mink droppings revealed that muskrats were the most important item in the summer dietary; fishes (golden shiners) and aquatic beetles were next in importance, these three items totaling 79.05 per cent of the bulk. In addition birds, frogs, small mammals, and reptiles were represented.

Analyses of the raccoon feces indi-

cated that wild fruits were by far the most important summer food, occurring in 84.66 per cent of the scats and comprising 72.12 per cent of their bulk. Corn, insects, small mammals, reptiles, a few frogs, and grass made up the remainder.

Availability appears to determine, in large measure, the food eaten by these animals. Except for the abundant frogs, both minks and raccoons appeared to be taking food in direct proportion to its availability.

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A VENTURE IN SONGBIRD MANAGEMENT

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Early in 1926 arrangements were made between the Bureaus of Plant Industry and Biological Survey of the United States Department of Agriculture for increasing the number of birds in an experimental chestnut orchard as a means of controlling nut weevils. The site assigned was the field station of the Bureau of Plant Industry at Bell, Prince Georges County, Md., about 15 miles northeast of Washington, D. C. Bell was a stop on an interurban electric railway, now abandoned; the nearest post office is Glenn Dale. Incorporated in the experimental area was a test orchard of Asiatic chestnuts planted many years ago by the late Walter Van Fleet. These showed marked resistance to the blight that was so fatal to the American chestnut, hence it was desired to get as many sound nuts as possible to facilitate propagation of the resistant types. As practically all insectivorous birds eat nut weevils (Balaninus), it was deemed that general bird attracting procedure was all that was required. The surroundings were basically favorable, comprising abundant shrub and tree growth with plenty of open space.

It may as well be said in the beginning that there were too many factors involved (e.g. the trees producing steadily increasing quantities of nuts) to permit definite appraisal of the effect of the multiplied bird population upon the chestnut weevils. The belief is held, however, that the weevils would have been more numerous but for the predatory attentions of the birds.

Management phases of the investigation are here reported upon.

Methods

The steps taken to increase the bird population were installation of: a bird bath, a 16-apartment martin house, and numerous bird boxes. The colony martin house was that illustrated in Figure 5 of Farmers' Bulletin 1456 (Kalmbach and McAtee, 1926) and the individual houses were like that shown in Figure 1c of the same publication. These were made of 5/8″ undressed cypress and stained brown outside. Their dimensions followed those given in Table 1 of the bulletin mentioned for nesting boxes for bluebirds, chickadees, titmice, house wren, crested flycatcher, and flicker.

Increasing the Birds

Results as to birds attracted and as to their productiveness may well be reported separately for two periods: 1926–27, when there was a smaller number of houses and less frequent observations; and 1928–31, with a larger number of bird boxes and more frequent inspections.

The writer was aided in the field work by his son Robert Bruce McAtee and on from one to several visits each by nearly all of the male employees at the time of the Division of Food Habits Research of the Biological Survey.

In 1926–27 there were, in addition to the martin house, 46 bird boxes evenly distributed over an area of about 2½ acres (18.4 boxes per acre). As to bird occupancy, counting anything from an

TABLE 1
NUMBER OF "BROODS"

Species	Year				Totals for four years
	1928	1929	1930	1931	
Starling	13	34	30	32	109
House wren	31	36	23	13	103
English sparrow	5	5	5	15	30
Purple martin	7	9	7	7	30
Bluebird	6	7	4	4	21
Crested flycatcher	1	1	—*	1	3
Flicker	1	—	—	—	1
Tufted titmouse	—	1	—	—	1
Yearly totals	64	93	69	72	298
Average per acre	18.3	26.6	19.7	20.5	21.3

* A nest was built but no eggs laid.

egg to fledged young as a "brood," there were in 1926: purple martin 3, house wren 11, bluebird 4, and crested flycatcher 1, a total of 19 or 7.6 to an acre. In 1927 there were: martin 4, wren 17, bluebird 4, English sparrow 5, starling 8, and flicker 1—39 in all or 15.6 "broods" per acre.

Prior to the 1928 nesting season, 52 additional bird boxes were put up, making a total, exclusive of the martin house, of 98 on a somewhat larger tract of about 3½ acres (28.1 boxes to the acre). It was impracticable to inspect the martin house (a brood was assumed for each two adults) but all of the others were examined at about fortnightly intervals during the nesting seasons of the four years 1928–31. Results as to "broods" more or less comparable to those cited for 1926–27 are given in the accompanying table (1). It should be borne in mind that these figures are not for pairs per acre as ordinarily given for breeding bird populations. The number of pairs present at any inspection could be given but not the total for a season, as banding, which would be required for that purpose, was not done.

Thus the management objective of merely increasing the number of birds on the area was easily attained. Experience, not only in this instance but in many others, indicates that increase of the bird population can be brought about by bird attracting measures on a previously undeveloped tract almost anywhere. At Bell, reckoning the average tree and bush nesting birds of the 3½-acre experimental plot at 16 pairs, the increase in adults alone, at certain seasons, was from 3 to 4 fold.

OCCUPANCY OF NEST BOXES

Net.—The net occupancy (Table 2) of the bird boxes varied during the 6 years from 32.6 to 71.4 per cent and averaged 53.9. Apparently under conditions similar to those at Bell, one may count upon about half of a liberal supply of nest boxes being productively occupied.

According to size of entrance.—The success on a "brood" basis of the different types of bird houses used in the project is summarized in Table 3.

There is little doubt that the diameter of the entrance hole is a very im-

TABLE 2
NET OCCUPANCY OF BOXES

[Number and percentage in which eggs or young were produced; renestings not considered.]

	Producing "broods"	*Percentage*
In 46 boxes		
1926	15	32.6
1927	28	60.8
In 98 boxes		
1928	49	50.0
1929	70	71.4
1930	51	52.04
1931	48	48.9
Average		53.9

portant factor affecting utilization of bird boxes. The starling and less surprisingly, the flicker would have none but the largest ($2\frac{1}{2}''$). The crested flycatcher also liked the larger openings and 3 out of 4 of its "broods" were produced in houses designed especially for this species. The tufted titmouse insofar as it approved of our designing at all, that is, in one case, took the box built for it. Probably better results with the more conservative hole-nesters can be obtained with hollowed-out logs in which the cavity follows the woodpecker pattern. From Table 3 it appears that the bluebird and the English sparrow prefer the $1\frac{1}{4}''$ opening, although they are not bigoted about it. The irrepressible house wren nested in every type of box available except the largest, but definitely favored the smaller sizes of entrances. One fact not revealed by Table 3 is that the wrens did not take well to the strict $\frac{7}{8}''$ or "size of a quarter" entrance usually recommended. No house with the opening exactly $\frac{7}{8}''$ was occupied, those with $1''$ or larger holes being preferred. A transverse slot making for easier management of the coarse twigs it uses so freely also seems very acceptable to the wren.

According to height.—Table 4 shows effective occupancy of the nest boxes according to their height from the ground. The boxes were intentionally placed low so as to make them readily accessible for inspection and cleaning. Removal of old nests, and sometimes control of parasites and intruders, is so necessary to continued utility of nest boxes that ease of access should always be maintained. Houses out of reach are not likely to be serviced, and if not kept free of old building material and pests probably will be little used. The few boxes placed at more than prevailing heights for the study were occupied almost exclusively by starlings. This species, however, manifested no strict requirement with respect to height of nest boxes, accepting some of all ele-

TABLE 3
EFFECTIVE OCCUPANCY* ACCORDING TO TYPE OF BOX, 1926–31

Type of box: Name in F. B. 1456 Dimensions Diameter entrance	House wren 4×4×6 $\frac{7}{8}$–$1''$	Chickadee 4×4×8 $1\frac{1}{8}''$	Titmouse 4×4×8 $1\frac{1}{4}''$	Bluebird 5×5×8 $1\frac{1}{2}''$	Crested flycatcher 6×6×8 $2''$	Flicker 7×7×16 $2\frac{1}{2}''$
Starling	—	—	—	—	—	117
House wren	57	30	26	7	11	—
English sparrow	—	4	29	2	—	—
Bluebird	—	—	15	8	6	—
Crested flycatcher	—	—	—	—	3	1
Flicker	—	—	—	—	—	2
Tufted titmouse	—	—	1	—	—	—

* That is resulting in production of eggs or young, including renestings in same box.

TABLE 4
EFFECTIVE OCCUPANCY ACCORDING TO HEIGHT OF NEST BOXES, 1928-31

Bird	Feet from ground								
	4	5	6	7	8	9	10	11	12
Starling	14	8	12	41	4	4	15	6	5
House wren	—	47	36	19	—	—	—	—	—
English sparrow	—	7	17	1	5	—	—	—	—
Bluebird	—	16	3	2	—	—	—	—	—
Crested flycatcher	—	—	1	2	—	—	—	—	—
Flicker	—	—	—	1	—	—	—	—	—
Tufted titmouse	—	—	1	—	—	—	—	—	—
Total occupancy	14	78	70	66	9	4	15	6	5
Broods per house of each type	1.55	2.23	2.69	3.66	4.5	4	3.75	6	5
All houses	9	35	26	18	2	1	4	1	1
Houses never occupied	4	2	3	2	—	—	—	—	—

vations. From Table 4 the conclusion appears safe that boxes at moderate heights will be well utilized by the common hole-nesting birds. Ignoring data relatively too scanty for significance, it would seem that boxes 5–7 feet from the ground were most effective in "brood" production.

According to degree of insolation.—In 1928 notes were taken on the degree of insolation to which the boxes were exposed and it has been assumed, possibly with some percentage of error, that the degrees of sun and shade remained about the same during the next 3 years. With a reservation in that respect, the data in Table 5 have been assembled. Without forcing the somewhat conflicting evidence into the straight jacket of formula, it seems warranted to say that, on the whole, houses in from 80–100 per cent sun were preferred and that those with 80–90 insolation were the most productive. Contrasting groups of 3 of the most, and least, sunlit boxes, we would have broods in

TABLE 5
EFFECTIVE OCCUPANCY ACCORDING TO INSOLATION, FROM FULL SUN (100) TO FULL SHADE (0), 1928–31

Bird	Percentage of insolation										
	100	90	80	70	60	50	40	30	20	10	Less than 10
Starling	57	8	17	—	—	5	—	3	7	2	10
House wren	62	4	8	—	10	4	2	—	3	—	9
English sparrow	9	1	—	—	1	7	—	—	—	—	12
Bluebird	12	4	—	—	1	—	—	—	—	1	3
Crested flycatcher	2	1	—	—	—	—	—	—	—	—	—
Flicker	1	—	—	—	—	—	—	—	—	—	—
Tufted titmouse	—	—	—	—	—	1	—	—	—	—	—
Total occupancy	143	18	25	—	12	17	2	3	10	3	34
Broods per hours of each type	2.8	3.6	3.57	—	3	2.12	2	3	3.33	1	2.43
Insolation all houses	51	5	7	—	4	8	1	1	3	3	14
Insolation of houses never occupied	4	—	1	—	—	1	—	—	—	1	4

TABLE 6
OCCUPANCY OF BIRD BOXES BY INTRUDERS

Animal	In 46 boxes		In 98 boxes				Totals
	1926	1927	1928	1929	1930	1931	
White-footed mouse	2	7	5	—	3	—	17
Paper wasps	24	13	38	25	45	35	180
Yellow jackets	1	—	—	—	—	—	1
Mud daubers	—	—	—	1	—	—	1
Bumblebees	1	—	—	—	—	—	1
Honeybees	—	—	2	—	—	—	2
Ants	—	3	2	—	—	1	6

proportion to houses 143:63::47:20. Since this is a false equation and requires substitution of 79 for 63 as the second term to rectify it, the advantage of the sunny group may be expressed as 79:63 or 1.25:1, or 20 per cent.

DEALING WITH INTRUDERS

White-footed mice, bumblebees, honeybees, yellow jackets, mud daubers, paper wasps, and ants appropriated the boxes to the extent shown in Table 6. Mostly simple removal, nothing scientific, was required to relieve the situation. Paper wasps were the most frequent and persistent intruders, so some experimentation was done toward their control. In various years they made nests in from 27.5 to 45.9 per cent of the boxes. Spraying with gasoline or Flit was ineffective short of drowning the insects. Tearing the nests out was the only remedy found useful and from 1 up to no fewer than 7 removals from the same house were required. In 40 per cent of the cases, however, one ejection sufficed. Nests can be removed on cool days or parts of days with little risk of stings from these wasps. For a fuller account of the paper wasp difficulties, see the articles by McAtee listed in Literature Cited.

SUMMARY

Near Glenn Dale, Md., installation of bird houses attracted birds so that in some seasons the normal population of the area was quadrupled. Brood production in typical years varied from 18.3 to 26.6 per acre. On the average, about half of the nest boxes were occupied. Diameter of entrance was probably the most important factor influencing birds in their choice of a home. The sizes ordinarily recommended for various birds were found satisfactory except in the case of the house wren which preferred an entrance an inch or larger in diameter. Boxes placed at moderate heights (5–7 feet) were well utilized and were most convenient for inspection and cleaning. Apparently from 80–90 per cent insolation was most favorable for brood production. Intruders were best dealt with by simple removal.

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MORTALITY OF WILDLIFE ON A TEXAS HIGHWAY

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Considerable interest has developed of late in the problem of wildlife mortality on our public highways (see Dickerson, L. M., the JOURNAL OF WILDLIFE MANAGEMENT, 1939, vol. 3, p. 104). In an attempt to gain some measure of the losses on the highways of Texas, I kept daily records (except for July and August) from February 1, 1938, to January 31, 1939, of mammals run down by motorists on the six miles of concrete highway between College Station and Bryan in Brazos County.

Traffic on this section of highway is heavier than average, increasing the hazard to wildlife, but this factor is compensated for in part by the relative scarcity of most kinds of mammals in this section of the state. I consider my data as probably slightly less than average for a similarly constructed six-mile section of highway in some other part in Texas, as, for example, the Trans-Pecos region. On unimproved highways, of course, the losses would tend to be much less, for it is common knowledge that the rate of mortality to wildlife, and man as well, increases directly with the degree to which a highway is improved for rapid transit.

Disregarding the months of July and August in which no data were recorded, the average monthly loss of mammals was 5, or nearly 10 per mile-year. If my data be nearly average for similar sections of "fast" highway in other parts of the state, the total number of mammals (not counting man) killed each year on the 15,675 miles of hard surfaced highways in Texas is 156,750. If we assume that a reduction of average speed on the highway from 50 m.p.h. to 30 m.p.h. will reduce highway mortality of wildlife from 10 a mile-year to, say, 4, the yearly loss on the 5,790 miles of graveled and unimproved roads in the State would amount to 23,160. Add this to the figure derived for the "fast" highways, and we get a total of 179,910.

This figure is for mammals alone. No record was kept of the birds, reptiles, and amphibians run down by motorists, but I gained the impression that during the ten months of observation the loss of birdlife was only about one-fifth that of mammals; reptiles, however, especially the painted terrapin (*Terrapene ornata*), fared much worse than did the mammals.

Highway mortality among the mammals was heaviest (77 per cent of the total) in fall and winter; nearly 50 per cent of the cottontails were killed in January and February. Seven of the eight opossums killed in September and October were young of the year. These data suggest that at least two natural factors were operating against them: (1) Winter is the season when both food and cover is at a minimum, inducing more movement on the part of the animals. This factor, in combination with overgrazing by livestock, would seem to account for the high mortality among the cottontails in January and February, especially when one considers that the vegetation at the sides of the highway was for the most part ungrazed by livestock. (2) Fall

TABLE 1

MONTHLY RECORDS OF MAMMAL MORTALITY FROM FEBRUARY 1, 1938, TO JANUARY 31, 1939, ON A SIX MILE SECTION OF CONCRETE HIGHWAY IN BRAZOS COUNTY, TEXAS

Species	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Total
Cottontail	6	2	2	1		—	—	2	2	3	3	6	27
Virginia opossum				1	1	—	—	4	4		1		11
Striped skunk						—	—	1					1
House cat	2					—	—	3					5
Armadillo		1		1		—	—						2
Domestic pig	1					—	—						1
Texas mole			1			—	—						1
Spotted skunk			1			—	—						1
Totals	9	3	4	3	1	—	—	10	6	3	4	6	49

is the season when the population has reached its yearly peak and when young of the year are searching for individual territories. This factor probably accounts for the high percentage of young opossums killed in September and October.

A third factor, induced by man, was over-grazing by livestock in pastures adjacent the highway. Grazing pressure is highest in fall and winter, hence herbivores such as cottontails come into direct competition with livestock at that season and the natural tendency would be for them to feed at the sides of the highway where food is more abundant. This inference is substantiated by the fact that most of the cottontails were killed at places on the highway adjacent to heavily stocked pastures.

It would seem that regulation of grazing by livestock will enter into any program of cottontail management in this section of Texas, especially in pastures adjacent to "fast" highways. Except for the opossum and the domestic pig, the loss per mile-year suffered by the other species listed was negligible and of slight economic importance.

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SEX AND AGE RATIOS IN SURVIVAL OF THE CALIFORNIA QUAIL

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This paper brings together records on 17,632 California Quail (*Lophortyx californica*), living and dead, for the purpose of analyzing sex and age ratios. Data were obtained from museum collections, hunters' bags, bird banders' reports and field observations (Table 1). represent with reasonable accuracy the actual sex composition of wild populations. A few reports that exhibited extreme unconformity, signifying atypical local conditions, are omitted from the totals and treated separately. Museum specimens were not used in the

TABLE 1

SOURCES OF DATA AND NUMBERS OF SPECIMENS AVAILABLE FOR SEX AND AGE RATIO STUDIES OF CALIFORNIA QUAIL

Sources	Sex ratio			Age ratio		
	♂	♀	♂♂:100 ♀♀	Adult	Immature	Imm: 100 Ad.
Museum collections (8 institutions)	927	650	143[1]	423	560	132
Field observations (3 observers)	6,251	5,588	112	803	1,763	220[2]
Banding records (12 operators)	1,535	1,363	113	821	1,231	150
Hunters' kill (53 hunters)	602	525	115	427	558	131

[1] Ratio not considered representative of field conditions (see text).
[2] Data from two atypical localities (see text).

All records were submitted or checked by reliable ornithologists. Acknowledgment is hereby made to the many who assisted in collecting these data, particularly to Ben Glading of the U. S. Forest Service, Roland Curtis of the California Division of Fish and Game, Wharton Huber of the Academy of Natural Sciences of Philadelphia, and Kenneth Porter of Woodland, California.

Sex ratio.—Records on sex ratio from hunting and banding operations and field observations agree quite closely (Table 1) and are considered to sex ratio compilations since collectors often select specimens according to their needs or interests.

The sex ratio in 15,728 birds from all sources except museum collections was 112.2♂♂ per 100 ♀♀. This approximates Stoddard's figure of 114♂♂ per 100 ♀♀ for the bob-white quail, in the Thomasville-Tallahassee region (6).

A definite annual cycle in sex ratio was indicated for the California quail: the proportion of males started at a low of 105♂♂:100 ♀♀ in early fall, rose to and remained at about 112♂♂ :100 ♀♀ during the late fall and winter, then mounted rapidly during

[1] Contribution from the division of Zoology, University of California at Davis.

late spring to reach a peak of 127♂♂:100♀♀ in June (Fig. 1).

The inequality of the sex ratio was more pronounced in some regions than in others. In the foothill range lands of central California males and females were roughly equal in number (103 ♂♂:100♀♀ in 1,821 specimens) during the winters (November–December) of 1936, 1937, and 1938; in the Sacramento Valley males concurrently predominated in the ratio of 136:100 (822 specimens).

Age Ratio.—Three age classes are recognizable from plumage characteristics: *juvenile*, *immature*, and *adult*. The juvenile plumage is lost in late summer and early fall when the birds are from two to six months of age. The first winter or immature plumage which follows is distinguished from the adult plumage by the mottling of the primary coverts as described by Sumner (7) and elaborated by Leopold (4). These feathers are retained through the first winter and spring, and are replaced by the solid gray coverts of the adult plumage in late summer when the birds are from 11 to 17 months of age.

Age ratio data from hunting and banding records, museum collections, and field observations do not agree closely (Table 1). The discrepancies are, however, largely if not entirely explicable on the basis of date and locality of operations, and there is no evidence that either trapping or shooting are selective in favor of one or the other age group. The records from field observations represent only two localities, both known to have an unusual preponderance of immature birds.[2]

[2] Field observations ordinarily provide no information on age ratio since immature and adult quail can be distinguished only in the hand; birds carrying artificial identification markers on the special study areas in San Mateo County (7) and at Davis (1) provide exceptions. These birds were recounted each month to produce the 2,566 records under "field observations" in Table 1.

The age ratio of immature to adult birds was 146:100 in 4,257 from all sources (July, August, and September records have been omitted to avoid specimens in molt.) The immature birds outnumbered older ones about 2 to 1 in the autumn but declined in number more rapidly during the winter and spring, so that by the beginning of summer the two groups were about equal (Fig. 2.).

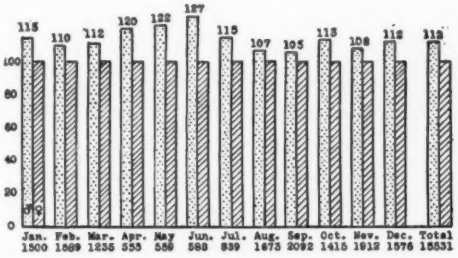

Fig. 1. Seasonal fluctuation in sex ratio of California quail populations. Figures at the top of each column indicate the number of males per 100 females; those under each column, the number of specimens examined (data from all sources except museum collections).

The proportion of young birds was considerably higher among females than among males as illustrated in the November–December totals: for females, the ratio of immature to adult birds was 191:100; for males, 136:100 (Table 2).

Age ratios showed considerable geographic variation. The central California foothills, during the three year

period 1936–38, supported a population in which immature birds only slightly outnumbered adults during November and December (118:100 in 807 specimens). The Sacramento Valley had

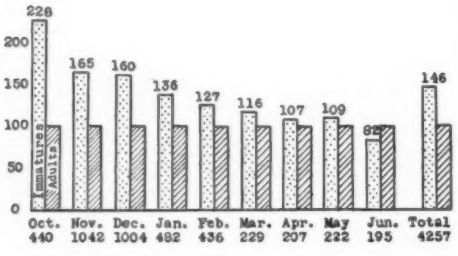

Fig. 2. Changes in age ratio of California quail populations during nine months of the year. Figures above each column indicate the number of immature per 100 adults, those below, the number of specimens examined (data from all sources).

concurrently nearly two young for every adult (180:100 in 600 specimens).

Age ratios also varied markedly from year to year in individual localities. The age ratio in the quail population of the University Farm at Davis was 150:100 in November of 1936; 235:100 in November, 1937; and 138:100 in November, 1938 (Table 3). Specimens from southeastern Glenn County in the same months showed ratios of 180:100 and 183:100 in 1936 and 1937, then a rise to 219:100 in 1938. In the foothills bordering the Sacramento Valley in Yolo, Placer, and El Dorado counties, the age ratio was 98:100 in 1936; 85:100 in 1937; and 155:100 in 1938.

Data were inadequate to trace historic fluctuations in age ratio, but museum specimens seem to indicate a progressive change since the earliest specimens were collected in the eighteen-forties. Among 105 winter (November to February) specimens taken in California before 1900, the ratio was 139:100; while in 270 winter specimens collected since 1900 it was 187:100.

Because of the wide geographic and chronographic variability in the age composition of California quail populations, more facts will be required before precise measurements and analyses can be attempted. The limitations of the present data are recognized. Figures are presented without claim of finality; analyses are made for their comparative rather than any absolute value.

DISCUSSION

At the end of the juvenile period (November), the age ratio of immature to adult individuals in an average quail population (records from all localities and years) is 165:100 (Fig. 2). The 100 adults in this population are, of course, the surviving remnants of the total of 265 young and old of the previous November. The survival percentage (Nov. to Nov.) accordingly is 38%.

Immature quail suffer greater losses than adults during the winter and spring so that by the beginning of the breeding season (April–June) they constitute only about half of the total population (99:100 in 622 specimens). From May of one year to May of the next year the total survival according to the 99:100 age ratio is 50%.

These 100 adult and 99 immature birds in May would, with the average May sex ratio of 122 ♂ ♂ : 100 ♀ ♀ provide 90 breeding pairs. If each pair produced 13 eggs (the average for 84 incubated nests; 2, 3, M.V.Z. coll. and JTE unpublished) a total of 1,170 eggs would result. By the following May these will be represented by 99 imma-

ture birds, a net survival from egg to one year of age of 8.5%.

Before the following November, members of the first year generation have molted their diagnostic primary coverts and become indistinguishable from the older birds. If, however, the 99:100 May ratio of these two age groups holds *in essentia* through the summer (the mortality of the two groups was about equal at Davis where intensive studies were made), about half the adults, that is 19% of the total November populations, will be yearlings. Immature birds, accordingly drop from 62% to 19% of the total population between their first and second November, a survival of 31%; all older birds (beyond their second November) drop from 38% to 19%, a survival of 50%. In summary:

Survival from potential egg to 12 months..... 8.5%
Survival from 6 months to 18 months (November–November).....31 %
Survival in all birds over 12 months (May–May).....50 %
Survival in all birds over 18 months (November–November).....50 %

Among the immature the sexes are about equally represented in early winter (Table 2). Thus, if the sex ratio at fertilization (primary ratio of Mayr, 5) is 100:100, an equal mortality of males and females is indicated for eggs and juvenile birds. By spring (April–June), the rather unsatisfactory data at hand seem to show a preponderance of females in the immature generation (60 im. ♂♂; 100 im. ♂♂ in 80 specimens, principally from one locality) indicating a first winter mortality somewhat higher for males than for females. The balance is reversed during the summer and by November the sex ratio of adult birds, which now includes the first year generation, strongly favors the males (140:100) (Table 2).

TABLE 2

NUMBERS OF CALIFORNIA QUAIL SPECIMENS FOR WHICH BOTH SEX AND AGE DATA ARE AVAILABLE

(November and December records only.)

Totals	
Adult males	298
Adult females	213
Immature males	406
Immature females	408
Sex ratios (males per 100 females)	
Immature	100
Adult	140
Age ratios (immature per 100 adults)	
Males	136
Females	191

By May this adult ratio has apparently advanced still farther (64 ad. ♂♂: 37 ad. ♀♀, principally from one locality). Thus female mortality is considerably greater than male mortality in adult birds, especially during the summer. According to the age ratio statistics, the total November to November survival for males is 42%, for females only 34%.

Survival figures thus far presented are based on data from all localities and years and represent average conditions in which year-to-year fluctuations in population are assumed to balance off so as to simulate stability. In such stable populations total annual losses are completely replaced each breeding season, the replacement (R) being the complement of the survival (S). In individual localities where populations fluctuate, replacement may still be determined directly from age ratio data, but the complementary factor must be multiplied by the net population change

$P\left(\frac{\text{current population level}}{\text{previous population level}}\right)$ in order to give the actual survival for the period.

Detailed population studies on the University of California Farm at Davis through three complete years provide a factual illustration (Fig. 3). The age ratio in November 1936 was 150:100, indicating a net summer replacement of 60% for 1936; somewhat less than the yearly replacement of 67% estimated to be normal for the area (Table 3). Despite this subnormal increment of young birds, the population had increased during 1936, and by November was 116% of that of November 1935. A high annual survival was obviously involved. Solving for the equation $S=P(100-R)$, the survival is found to be 46% as contrasted with the estimated normal 33%.

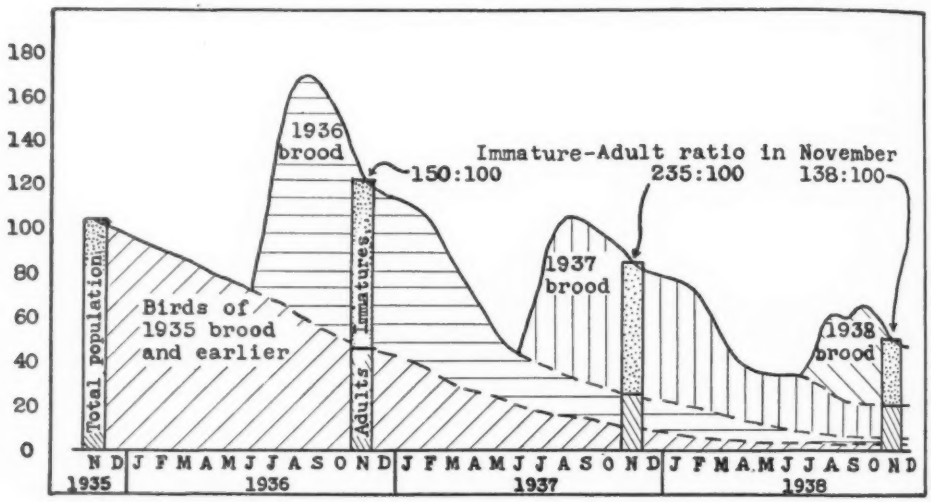

Fig. 3. Changes in the population of quail on the University of California Farm at Davis, 1935–1938. Figures at the left represent the actual number of birds. Columns show the population and age composition for November of each year. (Estimated normal ratio of immature to adult for this locality in November—200:100.)

The population by November, 1937 had dropped to 87, 70% of the 1936 level, and at the same time showed a strong preponderance of immature birds, 235:100. It is evident here that the better than average replacement indicated by the high age ratio was insufficient to make up for the severe loss of adults during the year. Reduced to a numerical basis the summer replacement was 70% (118% of normal), the total annual survival only 21% (63% of normal).

In 1938 the population decreased to 52. The low replacement, indicated by the sub-normal age ratio of 138:100 can account for part of this reduction, the rest is a consequence of high adult mortality. The summer replacement was 58% (69% of normal), the annual survival, 25% (75% of normal).

Less complete data linking age ratios

with conspicuous population changes are presented in Table 3 for three additional localities. These represent five year-to-year records, three involving population decline, and two population increase. Of the three "decline" records, all were accompanied by age ratios below average. In two of them (B, 1937 and C, 1937) this subnormality of age ratio was slight as compared with the drop in total population, and the losses, although divided, may be attributed largely to mortality. In the other case (D, 1938) the extreme subnormality of the age ratio suggests low replacement (possibly a certain degree of non-nesting) as the principal factor responsible for the decline.

In both instances of population increase (B, 1938 and C, 1938) the age ratios were higher than average. Whether the high replacement thus indicated adequately accounts for the increases in population cannot be determined without more definite census data; apparently a high survival of adults also was involved.

A geographic analysis of survival and replacement would require far more data than are now available. Only two regions are considered sufficiently represented for comparative treatment at

TABLE 3

POPULATION AND AGE RATIO DATA AND THE REPLACEMENT AND SURVIVAL PERCENTAGES DERIVED THEREFROM IN FOUR CALIFORNIA LOCALITIES DURING THE YEARS 1935 TO 1938

(Estimated normal figures for each locality are based on the author's evaluation of all available data, and must be regarded as very approximate; they are included merely for purposes of general comparison.)

Locality	Season	Population (% of preceding year)	Age ratio (im.:ad.)	No. of specimens	Replacement (% im. in total population)	Survival P(100 −R)
A	*Estimated normal*	*100%*	*200:100*	—	*67%*	*33%*
Lower Sacramento Valley (Davis) See Fig. 4	Nov.-Dec., 1935	105	—	—	—	—
	Nov.-Dec., 1936	122 (116%)	150:100	122	60%	46%
	Nov.-Dec., 1937	87 (70%)	235:100	87	70%	21%
	Nov.-Dec., 1938	52 (60%)	138:100	52	58%	25%
B	*Estimated normal*	*100%*	*200:100*	—	*67%*	*33%*
Upper Sacramento Valley (southeastern Glenn Co.)	Nov.-Dec., 1936	100+%	180:100	115	64 ± %	—
	Nov.-Dec., 1937	50 ± %	183:100	122	65 ± %	18 ± %
	Nov.-Dec., 1938	120 ± %	219:100	102	69 ± %	38 ± %
C	*Estimated normal*	*100%*	*110:100*	—	*52%*	*48%*
Hills bordering lower Sacramento Valley (Yolo, Placer & El Dorado Counties)	Nov.-Dec., 1936	100+%	98:100	226	49 ± %	—
	Nov.-Dec., 1937	25 ± %	85:100	76	46 ± %	14 ± %
	Nov.-Dec., 1938	150 ± %	155:100	46	61 ± %	59 ± %
D	*Estimated normal*	*100%*	*200:100*	—	*67%*	*33%*
Central San Diego County	Nov.-Dec., 1938	40 ± %	73:100[1]	487	42 ± %	23 ± %

[1] Data collected in late summer, mainly August and September.

present, and for these only three years of records are at hand. The central California foothills, according to this information, have an annual replacement rate of 52% as compared with 66% for the Sacramento Valley; the foothills have a survival rate of about 36%, as against 28% for the Valley. Although these figures cannot be considered absolutely characteristic of the regions in question, it should be noted that the population changes in the two regions during this period were closely parallel. The survival and replacement determinations should therefore have comparative if not absolute value.

CONCLUSION

The relatively high proportion of young birds to be found in the November-December quail populations of a region such as the Sacramento Valley indicates a low survival of birds past their first winter, and a compensating high net replacement with young birds during the breeding season. Under such conditions game managers should, it would seem, concentrate their attention on factors of the adult environment, particularly the winter environment. In the foothills of central California, where the proportion of young birds in the population is small, adult survival is comparatively good, but the summer replacement with young birds is poor. Attention in such regions might well be directed toward factors of the summer environment that affect nest, egg, and juvenile mortality.

These conclusions should be applicable to other species which lend themselves to age composition analysis. A comparison of waterfowl age ratios in the five North American "Flyways" should provide information on the relative significance of nesting (eggs and young) and shooting (adult) losses in the five population groups.

When combined with census data, age ratio statistics are valuable in comparing the relative importance of juvenile and adult mortality during periods of population decline or increase. They should prove particularly useful in evaluating certain of the factors which influence population fluctuations of cyclical species such as the ruffed grouse.

SUMMARY

1. A total of 17,632 sex and age records on California quail (*Lophortyx californica*) from various parts of California are summarized and analyzed.

2. Sex ratios averaged 112.2♂♂:100♀♀; varied during the year from 105:100 in September to 127:100 in June; and geographically from 103:100 in the central California foothills to 136:100 in the Sacramento Valley.

3. Age ratios progressed from over 200 immature:100 adult in the fall, to 100:100 in late spring, averaging 146:100. Early winter ratios showed 136 im.:100 ad. for males and 191:100 for females. In the Sacramento Valley during November and December the age ratio was 180:100, while in the adjacent foothills at the same time it was 118:100. Local ratios changed considerably from year to year. The ratio in museum specimens collected before 1900 was 139:100 and for those taken since 1900 it has been 187:100.

4. Based on the total data in hand, average survival from potential egg to birds one year of age is 8.5%; from 6 to 18 months of age it is 31%; for birds over 12 months it is 50% per year; for

birds over 18 months, 50% per year. The mortality rate is higher in females than in males, particularly during the summer.

5. In stable populations survival (S) and replacement (R) are complementary; in fluctuating populations the complement of the replacement must be multiplied by the net population change (P) in order to determine survival. [S = P(100 − R)].

6. Net annual replacements (as of November) in the quail population of the University Farm at Davis during three consecutive years varied from 58% to 70% (estimated normal, 67%); annual survival varied from 21% to 46% (estimated normal, 33%).

7. In eight year-to-year records from four localities, population decline is attributable largely to low survival in one instance, to low replacement in one, and to a combination of the two factors in three. High survival was responsible for population increase in one instance; a combination of high survival and high replacement in two.

8. The net annual replacement (as of November) during the period 1936–38 was 66% in the Sacramento Valley, 52% in the adjacent foothills; the annual survival was about 28% in the Valley and 36% in the foothills.

9. It is suggested that in localities where high age ratios indicate low annual survival and high annual replacement, attention of game managers should be directed to the winter environment. In the reverse situation summer factors should receive primary attention.

10. Age ratio data should prove useful in comparing nesting and shooting losses of waterfowl in the five North American flyways. They should also be of service in evaluating certain of the factors which influence population fluctuations and cycles.

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SOUTH FORK (MONTANA) BEAVER SURVEY: 1939

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The South Fork Beaver Survey was carried out as a co-operative project by the writer, a Special Deputy Game Warden, acting for the Montana Fish and Game Commission, and Raymond M. West, Junior Biologist, for the Flathead National Forest. For some years both the Commission and the Forest Service had been interested in the possibility of better management of the state's beaver; but the necessary information on which to base a program was lacking.

Choice of the South Fork of the Flathead as an area in which to make a study of the problems involved was dictated largely by topographical factors. It is a convenient geographical unit, set off from the surrounding territory by high and definite natural barriers. There is no privately-owned land within its boundaries, no lumbering or domestic livestock grazing to bring in conflicting issues. It is large enough so that the results obtained could fairly be taken as a yard-stick, yet not so large but that it could be examined with the requisite thoroughness in one season.

Three ranger districts comprising more than a million acres and approximately eight hundred miles of waterways lie within this drainage. From Coram, at the confluence of the South and Middle forks, to Spotted Bear, fifty miles south, the country is accessible by a motor-road following the main valley. From Spotted Bear to the head-waters is accessible only by horse or foot-trail, or by air.

The project was formally approved in June, 1939 by the Montana Fish and Game Commission and the Forest Service; West and myself were designated to act and preparatory work was begun at once. The most important objectives of the survey were as follows:

1. To determine present beaver population and distribution in the area.

2. To determine areas now normally stocked, under-stocked, over-stocked.

3. To study management factors: transplantation, poaching, disease, loss through predators, possibilities of revenue.

In laying plans for work in the field, the keeping of sufficiently detailed and accurate records proved to be a major problem. The final decision was that in addition to a diary, a series of maps should be used for entering pertinent information as to beaver numbers, locations, and forage areas. Accordingly tracings of the various examination-units were made from a one-inch map on pocket-sized sheets of profile paper. These field-maps were found to be invaluable and at the close of the survey were reduced to a single overlay. After several weeks in the field it was found convenient to carry along a summary of each day's work in order that the status of the survey could be tabulated at any time without reference to the diary. This daily summary was under the heads here indicated.

Date	Name of stream	Number of colonies	Number of beavers	Stream mileage	Total mileage	Forage areas

The amount and quality of forage, as well as other factors affecting the beaver population and its distribution, vary widely from one location to another. It was the task of the survey to analyze these factors from the standpoint of future possibilities as well as present conditions. In tabulating the information, five classifications of waterways were used:

Class 1: Most favorable location for beavers. Ample forage of preferred types; room for expansion, reliable water-supply; topography favorable for dams, lodges, and feed production. Support at least six colonies per mile.

Class 2: Favorable location for beavers. Same requirements as above but expansion limited by topography. Support at least four colonies per mile.

Class 3: Fair location for beavers. Forage not so plentiful or made up to some extent of less desirable types. Room for expansion strictly limited. Water-supply variable. Support at least two colonies per mile.

Class 4: Marginal location for beavers. Forage made up of less desirable types: alder, swamp birch, etc. Topography steep and rocky; water-supply unreliable. Support only scattered beavers.

Class 5: Unfavorable.

The elements that go to make up each classification operate, of course, with varying intensity and every stream contains within its length examples of several different classes. Hence in making the stream tabulations it would have been possible to subdivide in endless and confusing detail. The attempt, however, was to obtain an idea of the possibilities of the stream as a whole.

A few explanatory notes will aid the reader's understanding of the following tabulations:

1. For censusing, five was used as the standard number of animals in an active colony. This figure was increased or decreased whenever examination indicated either more or less than normal activity.

2. The acreages given are estimates but the mileage figures were checked against markers on the trails.

3. The term "forage area" indicates not the total amount of forage available, but the area of concentrated beaver feed. Carrying capacity was calculated on a per-mile, not a per-acre, basis.

Only the Class 1 stream tabulation and the recapitulation are presented.

With regard to a beaver management program, the survey disclosed numerous transplantation possibilities, both to modify the distribution of the present population and to increase that population by bringing in beavers from the outside. Since few areas within the drainage were up to or over their normal carrying capacities, introduction of beavers from outside sources showed the most promise. Wherever possible, the colonization areas should be those where natural barriers have prevented or tend to prevent natural migration.

During the period when the survey was under contemplation, its value and the value of a management program were questioned on the grounds that beavers have been protected from trapping in Montana for many years, that the South Fork game patrols have tended to prevent illegal trapping in that area, and that the South Fork

beaver population should therefore be at its maximum.

It became an objective of the survey to test this theory. From the evidence collected it is plain that neither natural barriers, nor laws and game patrols have been able to protect the South Fork beavers from wide spread illegal trapping. Since no evidence of abnormal losses through predators or disease was discovered, it is fair to assume that the most important limiting factor is poaching. Any management program adopted should include adequate protection against this hazard.

One of the objectives of the survey was the development of methods that might be applied to future surveys in this and other areas. A few statistical notes on the survey are in order to show what was accomplished and how. The survey occupied the time of one man

CLASS I
STREAM TABULATION

Stream	Forage area	Stream mileage	Population		Notes
			Present	Potential	
Big Prairie District					
Danaher Meadow	1,500	6	207	400	Fully stocked due to elk damage to forage.
Danaher at Basin	83	2	16	100	Depopulated by poachers and recommended for planting.
Bar	50	2.5	5	40	
Young's	300	6	63	200	Includes lower end of Hahn Creek.
Catchem	30	2	18	40	
Gordon	84	5	58	150	Under-stocked, recommended for planting.
Pendant Creek and Lakes	40	4	—	50	No beaver, recommended for planting.
Big Salmon Lake	20	1	25	30	
White River	100	1.5	50	50	Fully stocked between Cliff and Peggy Creeks
Totals	2,207	30	442	1,060	
Spotted Bear District					
Spotted Bear River	60	1	27	40	Recommended for planting above Pentagon. Natural barriers prevent migration.
Bunker	75	4	34	125	Partially depopulated by poachers.
Totals	135	5	61	165	
Coram District					
Graves Meadow	80	2	30	70	Population has declined recently.
Handkerchief Lake	10	1	12	30	Evidence of poaching.
Emery Meadow	20	1	20	30	Normally stocked.
Totals	110	4	62	130	
Class 1 Totals	2,452	42	609	1,355	

RECAPITULATION

District	Forage Area	Stream Mileage	Population	
			Present	Potential
Big Prairie				
Class 1	2,207	30	442	1,060
Class 2	60	13	87	295
Class 3	98	31	116	297
Class 4		70	8	
Totals	2,365	144	653	1,652
Spotted Bear				
Class 1	135	5	51	165
Class 2	214	22	82	325
Class 3	57	42	77	340
Class 4		42		
Totals	406	111	220	830
Coram				
Class 1	110	4	62	130
Class 2	78	7	65	125
Class 3	12	25	32	175
Class 4		22		
Totals	200	58	159	430
Grand totals	2,971	313	1,032	2,912

for three months. This includes periods spent in office-work and in other cooperative activities such as fish-planting, law enforcement, and fire-control. In sixty days of actual travel, 378 miles of waterway were examined and 773 miles altogether were covered either on horseback or on foot. Car mileage is omitted as having no particular significance. The per day coverage was 12.6 miles, including 6.1 miles of stream examination. Every beaver community and forage area of any importance within the watershed was visited.

Since data for comparison is lacking, it is not known whether or not this is the maximum output possible for work of this type. But it is plain that, aside from an increase in the stream mileage examined per day, the efficiency of survey work can best be improved by eliminating lost motion; that is, examination of barren waterways. Information concerning the location of beaver communities and forage areas, obtained from men who were familiar with the territory, was very valuable. Without it the project could not have been completed within the time allotted. But this information was uncorrelated and often unavailable when it would have been most useful. There is no apparent reason why it could not be assembled in advance and used as the basis for a more systematic work-plan.

Upon consideration of the findings of the survey, the Montana Fish and Game Commission and the Forest Service decided to extend their cooperative agreement with the immediate objective of inaugurating the transplantation program recommended in the report.

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NOTES

The death on December 3 of Dr. Royal N. Chapman, Dean of the Graduate School, University of Minnesota, deprives the profession of wildlife management of one of its staunchest friends and the science of animal ecology of one of its most scholarly members.

Dr. Chapman initiated Ralph T. King's Minnesota researches and wildlife courses which became the present wildlife school. Every important ecological research in the north-central region was dependent on him in some degree for guidance, criticism, and encouragement. His book, "Animal Ecology," has been one of the foundations for quantitative work in the wildlife field. At the time of his death he had nearly completed a brilliant series of experiments seeking to explain the nature of synchronism in population cycles. His scientific leadership is known and acknowledged by all ecologists, but only a few were privileged to know his warm personal enthusiasm for wildlife as an esthetic resource.—Aldo Leopold.

The Eighth American (Pan American) Scientific Congress will be held in Washington, D. C., May 10–18, 1940 under the auspices of the Government of the United States of America. Scientific institutions and organizations are cordially invited to send representatives. Sections probably of most interest to our members are: Biological Sciences, Chairman, Dr. Edwin G. Conklin of Princeton University, and Agriculture and Conservation, Chairman, Dr. Hugh Bennett, Chief, U. S. Soil Conservation Service.

The U. S. Civil Service Commission (Washington, D.C.) announces examinations for Junior Professional Assistant at $2000 a year, applications for which must be on file early in February. The examinations cover 28 classifications of which Junior Biologgist, Junior Forester, Junior Range Examiner, Junior Soil Scientist, and Junior Veterinarian may offer an opportunity for some of our members. The examinations are open only to citizens of the United States, between college graduation and 35 years of age, who have completed a full 4-year course leading to a bachelor's degree in college or university of recognized standing with a major course in the subject for which examination is taken.